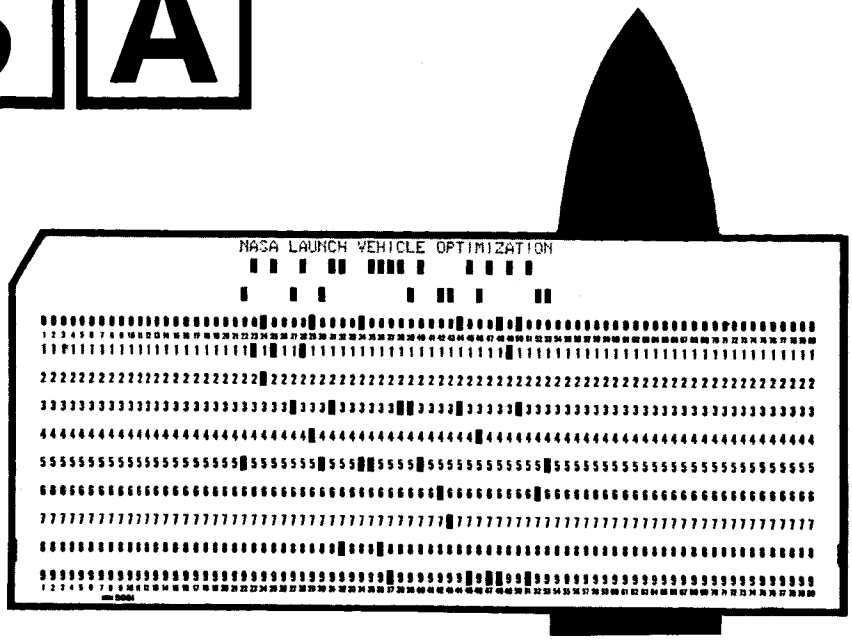
NASA



LAUNCH VEHICLE OPTIMIZATION

PHASE II FINAL REPORT

Volume III

Techniques Development

University of Michigan

LSI

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to

Office of Launch Vehicle and Propulsion Program
NASA Headquarters
Washington, D.C.

LAUNCH VEHICLE OPTIMIZATION

PHASE II FINAL REPORT

September 1965

Prepared by
Instrument Division
Under
Contract NASw-938

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ABSTRACT

VOLUME III

TECHNIQUES DEVELOPMENT - UNIVERSITY OF MICHIGAN

This third part of a three-volume final report contains documentation of a unique approach to the simulation of the behavior of complex physical systems, performed as part of a Launch Vehicle System Optimization (LVO) Program. This approach has been adapted to a digital computer and is known as the Performance Simulator. The methodology utilized within the Simulator in solving the system problem is one which proceeds from "desired results" through an analysis of an "Element Descriptor Library" to form an algorithm which models system performance in terms of known input parameters. The most critical portion of the methodology is the compilation of the "Element Descriptor Library" which contains the physical laws governing the behavior of the constituent elements of the system. An ancillary program, Regression, which may be utilized in developing the Library, is also documented in this volume.

FOREWORD

VOLUME III

TECHNIQUES DEVELOPMENT - UNIVERSITY OF MICHIGAN

A final report in three Volumes is herewith submitted by Lear Siegler, Inc., Instrument Division to the National Aeronautics and Space Administration Headquarters in fulfillment of Contract NASw-938. The study, entitled Launch Vehicle Optimization Study -- Phase II, was pursued under the technical direction of the Launch Vehicle and Propulsion Program Office, Code SV, NASA Headquarters, by the following participant organizations:

- LSI Instrument Division
- LSI Defense Systems Operations
- The University of Michigan

This summary report of the Phase II Launch Vehicle Optimization Study is contained in three separate volumes.

• Volume I Concept Development And Application	Volume I contains a general review of the program, an exposition of the PRESTO concept and techniques, a presentation of its application to a Study Launch Vehicle System, and a discussion of special problems and significant achievements.
• Volume II Techniques Development - Lear Siegler, Inc.	Volume II contains a comprehensive review of the PRESTO simulation and optimization techniques, as formulated and applied at LSI, in addition to a description of the Study Launch Vehicle System to be analyzed.
• Volume III Techniques Development - University of Michigan	Volume III contains a report of related efforts compiled by the University of Michigan under the direction of Dr. Frank H. Westervelt. It includes documentation on the Westervelt Performance Simulator and the U of M Regression Routine.

PART A

PERFORMANCE SIMULATOR MANUAL

FOREWORD

The Performance Simulator is a computer program designed specifically for the purpose of constructing a wide variety of special computer programs that have the ability to simulate or represent the behavior of systems. The types of systems that may be so treated are limited only by the availability of descriptors for the components or elements of the system.

The creation of these descriptors is by no means a trivial task. Indeed, the development of a logically complete and consistent set of descriptors is the most difficult task facing the user of the Performance Simulator Program.

However, it should be recognized that two groups of users exist. In many cases, the two merge into a single person but it is important to identify both types:

1. The Systems Analyst whose task it is to procure, encode, and test the descriptors for the system elements.

2. The Systems Synthesist whose task it is to configure collections of elements to form systems and study the behavior of these aggregations.

The following material is designed to serve as a self-contained reference manual for both the Systems Analyst and Systems Synthesist.

TABLE OF CONTENTS

1 INTRODUCTION

The Performance Simulator utilizes the capability of modern digital computers to produce a program which will simulate the performance of a system in machine translatable language.

The information that is required by the Performance Simulator consists of the following:

a. Source Program.
b. Element Descriptor Library.

The Source Program describes the particular problem under consideration to the Performance Simulator. The Element Descriptor Library describes the physical laws or relationships for each element in the system to the Performance Simulator.

This manual was written to delineate the rules for communicating with the Performance Simulator and to provide a complete discussion of the logic used by the Performance Simulator. The reader is assumed to be generally familiar with Michigan Algorithmic Decoder (MAD) machine language.

The Performance Simulator Manual is intended to give enough detailed information so that a person can use the Performance Simulator effectively to produce a system performance simulation. Some sections of this manual may require careful thought to realize fully the capability offered by the Performance Simulator.

The Performance Simulator is currently available on both the 704 and 7090 IBM computers. It could, however, be adapted to any digital computer. All information will be conveyed to the Performance Simulator on 80-column IBM cards.

2 SOURCE PROGRAM

The Performance Simulator is a digital computer program designed to simulate a physical system in the form of a computer program in machine translatable language. The information required by the Performance Simulator includes the Source Program which consists of the following:

a. System Description
b. Input Parameters
c. Desired Results
d. New Element Tape

2.1 SYSTEM DESCRIPTION

A physical system consists of a collection of interconnected elements. In order to simulate such a system, it must be described to the Performance Simulator in an unambiguous manner. This requires the communication of the following information:

a. The elements that comprise the system.
b. The attachments associated with each of these elements.
c. The interconnection of these attachments in the system.

2.1.1 Elements

Each element in the system must be uniquely identified to the Performance Simulator. This identification is implemented through use of an Element Name and, if necessary, an Element Identifier.

2.1.1.1 Element Names

Element Names are restricted to six or less alpha-numeric characters. No restrictions are placed on the choice or ordering of these characters, but it is most beneficial to choose the name so that it conveys a close correspondence to the normal name. Once an element has been given a name, all reference to this particular element must agree exactly with the given name.

Examples of Element Names

Element	Element Name
Resistor	RES
Battery	BATT
Amplifier	AMPL

2. 1. 1. 2 Element Identifiers

If a system has more than one element with the same name, Element Identifiers must be used to avoid ambiguity. Element Identifiers are restricted to six or less alpha-numeric characters. No restricitions are placed on the choice or ordering of these characters.

Once an element has been identified in a system, all reference to this particular element must contain both the Element Name and Element Identifier. If a reference is made to an identified element by the Element Name alone, the Performance Simulator interprets this as a reference to all elements in the system with the same given name.

The Element Identifier follows the Element Name and is separated from it by a comma.

Examples of Element Names With Element Identifiers

Element	Element Name	Element Identifier	E.N., E.I.
Resistor	RES	131	RES, 131
Battery	BATT	A1	BATT, A1
Amplifier	AMPL	15	AMPL, 15

2. 1. 2 Attachments

Each attachment associated with a particular element must be uniquely identified to the Performance Simulator. This identification is implemented through the use of an Attachment Name. Should the system interconnections require that a particular attachment branch out to more than one other attachment, each of these branches must also be uniquely identified. This identification is implemented through the use of Attachment Branch Identifiers.

2. 1. 2. 1 Attachment Names

Attachment Names are restricted to six or less alpha-numeric characters. No restrictions are placed on the choice or ordering of these characters, but it is most beneficial to choose the name so that it conveys a close correspondence to the normal name. Once an attachment has been given a name, all reference to this particular attachment must agree exactly with the given name.

The Attachment Name follows the Element Identifier in parentheses. If the Element Identifier can be omitted, the Attachment Name follows the Element Name in parentheses.

Examples of Attachment Names

Element	Element Name	Attachment Name
Resistor	RES	1
Battery	BATT	POS
Amplifier	AMPL	PLATE

2.1.2.2 Attachment Branch Identifiers

If there is more than one branch from an attachment, Attachment Branch Identifiers must be used to avoid ambiguity. Attachment Branch Identifiers are restricted to six or less alpha-numeric characters. No restrictions are placed on the choice or ordering of these characters.

The Attachment Branch Identifier follows the Attachment Name and is separated from it by a comma. The pair is enclosed in parentheses.

Examples of Attachment Names With Attachment Branch Identifiers

Element	Attachment Name	Attachment Branch Identifier	(A.N., A.B.I.)
Resistor	1	Q	(1,Q)
Battery	POS	D7	(POS,D7)
Amplifier	PLATE	63	(PLATE,63)

There are four cases that occur when defining an unambiguous attachment branch in a system. The statement, which defines an unambiguous attachment branch, is called an Attachment Branch Address.

Case 1. Element Identifiers and Attachment Branch Identifiers Required.

Element	E.N.	E.I.	A.N.	A.B.I.	Attachment Branch Address E.N., E.I. (A.N., A.B.I.)
Resistor	RES	131	1	Q	RES, 131(1, Q)
Battery	BATT	A1	POS	D7	BATT, A1(POS, D7)
Amplifier	AMPL	15	PLATE	63	AMPL, 15(PLATE, 63)

Case 2. Element Identifiers Not Required and Attachment Branch Identifiers Required.

Element	E.N.	A.N.	A.B.I.	Attachment Branch Address E.N. (A.N., A.B.I.)
Resistor	RES	1	Q	RES(1, Q)
Battery	BATT	POS	D7	BATT(POS, D7)
Amplifier	AMPL	PLATE	63	AMPL(PLATE, 63)

Case 3. Element Identifiers Required and Attachment Branch Identifiers Required.

Element	E.N.	E.I.	A.N.	Attachment Branch Address E.N., E.I. (A.N.)
Resistor	RES	131	1	RES, 131(1)
Battery	BATT	A1	POS	BATT, A1(POS)
Amplifier	AMPL	15	PLATE	AMPL, 15(PLATE)

Case 4. Element Identifiers and Attachment Branch Identifiers Not Required.

Element	E.N.	A.N.	Attachment Branch Address E.N. (A.N.)
Resistor	RES	1	RES(1)
Battery	BATT	POS	BATT(POS)
Amplifier	AMPL	PLATE	AMPL(PLATE)

The four cases given above encompass all possible ways of defining an unambiguous attachment branch in a system.

2.1.3 Connections

The interconnection of the element attachments in the system describes the particular system configuration to the Performance Simulator. These interconnections are conveyed to the Performance Simulator through the use of Connection Statements. These Connection Statements must be preceded by the declaration CONNECTIONS.

2.1.3.1 CONNECTIONS. Declaration (Abbreviation CN's)

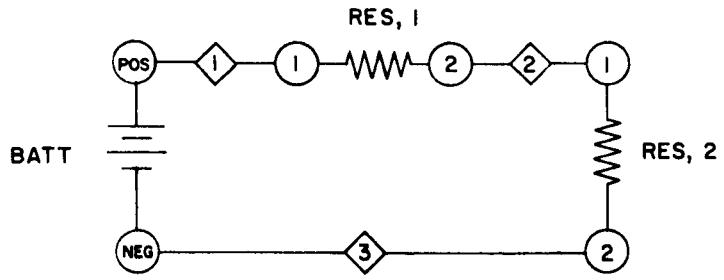
The declaration CONNECTIONS. must precede the Connection Statements. The declaration CONNECTIONS., which is located in columns 2 through 13, prepares the Performance Simulator to receive the Connection Statements.

2.1.3.2 Connection Statements

A Connection Statement conveys to the Performance Simulator an unambiguous interconnection of two attachments in a system. A Connection Statement consists of two uniquely defined Attachment Branch Addresses separated by the word TO which is set off by commas. Connection Statements will be located one per card starting in column 5.

Examples Illustrating Connection Statements

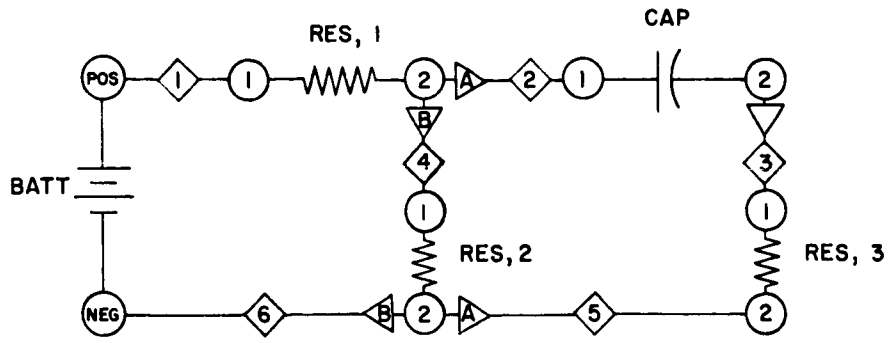
Example 1.



The following Connection Statements convey the interconnections of the above system to the Performance Simulator in an unambiguous manner.

```
Columns   1 2   5
          CONNECTIONS.
            BATT(POS), TO, RES, 1(1)
            RES, 1(2), TO, RES, 2(1)
            RES, 2(2), TO, BATT(NEG)
```

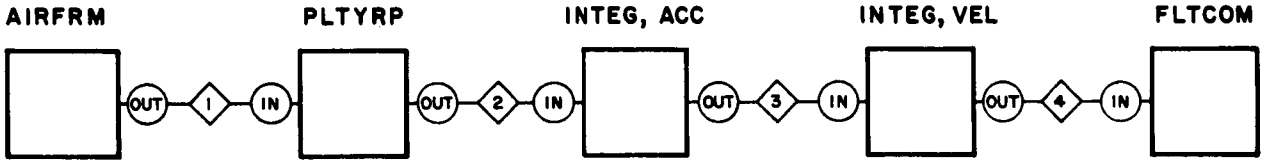
Example 2.



The following Connection Statements convey the interconnections of the above system to the Performance Simulator in an unambiguous manner.

Column	1	2	5
		CONNECTIONS.	
			BATT(POS), TO, RES, 1(1)
			RES, 1(2, A), TO, CAP(1)
			CAP(2), TO, RES, 3(1)
			RES, 1(2, B), TO, RES, 2(1)
			RES, 2(2, A), TO, RES, 3(2)
			RES, 2(2, B), TO, BATT(NEG)

Example 3.



The following Connection Statements convey the interconnections of the above system to the Performance Simulator in an unambiguous manner.

Columns	1	2	5
		CONNECTIONS.	
			AIRFRM(OUT), TO, PLTYRP(IN)
			PLTYRP(OUT), TO, INTEG, ACC(IN)
			INTEG, ACC(OUT), TO, INTEG, VEL(IN)
			INTEG, VEL(OUT), TO, FLTCOM(IN)

2.2 PARAMETERS

Parameters are used to describe the characteristics or physical relationships of elements that compose the system. Some examples of parameters are: voltage, resistance, current, and power. Each parameter used in the system must be uniquely identified to the Performance

Simulator. This identification is implemented through use of Parameter Names.

Parameter Names are restricted to six or less alpha-numeric characters. The first character of the Parameter Name must be an alphabetic character. No restrictions are placed on the choice or ordering of the remaining characters but it is most beneficial to choose the name so that it conveys a close correspondence to the normal name. Once a parameter has been given a name, all reference to this particular parameter must agree exactly with the given name.

2.2.1 Input Parameters

Input Parameters are the parameters which the user is willing to specify in order to obtain some desired results. Input Parameters are conveyed to the Performance Simulator through Input Parameter Statements, which must be preceded by the declaration INPUT PARAMETERS. .

2.2.1.1 INPUT PARAMETERS. Declaration (Abbreviation IN's)

The declaration INPUT PARAMETERS. must precede the Input Parameter Statements. The declaration INPUT PARAMETERS., which is located in columns 2 through 18, prepares the Performance Simulator to receive the Input Parameter Statements which follow it.

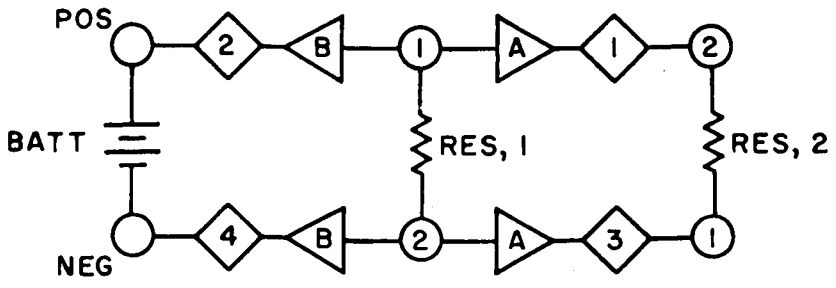
2.2.1.2 Input Parameter Statements

The Input Parameter Statements communicate the Input Parameters to the Performance Simulator. All Input Parameters are conveyed to the Performance Simulator at a uniquely defined attachment branch which may or may not be identified.

Input Parameter Statements consist of a Parameter Name followed by an Attachment Branch Address which is enclosed in parentheses. The Parameter Name must correspond exactly to the name assigned to this particular parameter in the Element Descriptor Library.

The Input Parameter Statements will be located starting in column 5.

Examples Illustrating Input Parameter Statements



Suppose the user wishes to declare the following parameters as Input Parameters:

Voltage at the positive terminal of the battery.

Current in attachment branch labeled A of attachment 1 of resistor 1.

In this case the following statements would be appropriate:

Columns	1	2	5
		INPUT PARAMETERS.	
			VOLTS(BATT(POS))
			AMPS(RES, 1(1, A))

2.2.2 Desired Results

Desired Results are the parameters which the user wishes to obtain as a function of the Input Parameters. Desired Results are conveyed to the Performance Simulator through Desired Result Statements, which must be preceded by the declaration DESIRED RESULTS. .

2.2.2.1 DESIRED RESULTS. Declaration (Abbreviation DS's)

The declaration DESIRED RESULTS. must precede the Desired Result Statements. The declaration DESIRED RESULTS. , which is located in columns 2 through 17, prepares the Performance Simulator to receive the Desired Result Statements which follow it.

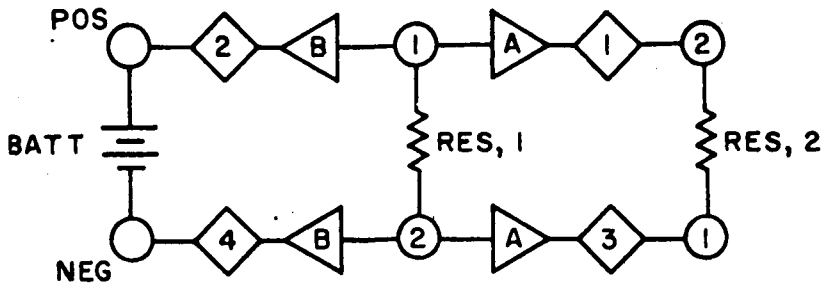
2.2.2.2 Desired Result Statements

The Desired Result Statements communicate the Desired Results to the Performance Simulator. All Desired Results are conveyed to the Performance Simulator at a uniquely defined attachment branch which may or may not be identified.

Desired Result Statements consist of a Parameter Name followed by an Attachment Branch Address which is enclosed in parentheses. The Parameter Name must correspond exactly to the name assigned to this particular parameter in the Element Descriptor Library.

The Desired Result Statements will be located starting in column 5.

Examples Illustrating Desired Result Statements



Suppose the user wishes to declare the following parameters as Desired Results:

Voltage at the negative terminal of the battery.

Current at the attachment branch labeled B of attachment 1 of resistor 1.

In this case the following statements would be appropriate:

Columns	1	2	5
		DESIRED RESULTS.	
			VOLTS(BATT(NEG))
			AMPS(RES, 1(1, B))

2.3 NEW ELEMENT TAPE (Abbreviation NW's)

The majority of the work done by the Performance Simulator is in the production of the Generated Program, which is that portion of the Complete Program that will yield the Desired Results in terms of the Input Parameters. The function of the New Element Tape is to organize this Generated Program into a Complete Program in machine translatable language.

The declaration NEW ELEMENT TAPE. must precede the New Element Tape. The declaration NEW ELEMENT TAPE., which is located in columns 2 through 18, prepares the Performance Simulator to receive the New Element Tape. The statements and instructions in the New Element Tape must be written in standard MAD format except for the special indicator symbols. The meaning and use of these special indicator symbols (-), (+), and (⊕) are discussed in Section 2.3.4.

The New Element Tape is divided into the following three sections:

a. Prologue
b. Epilogue
c. Calculations

2.3.1 Prologue

The Prologue section is assigned the task of initiating the Generated Program into an acceptable program in machine translatable language. Included in the Prologue section are such things as specifying the input and output format, reading in and printing out the Input Parameter values, and printing of the Desired Results. The function of the Prologue is to provide the Performance Simulator with the actual computer language statements which perform these functions.

The Prologue section consists of all the statements following the declaration NEW ELEMENT TAPE. up to and including the statement with the third (-) symbol encountered in column one of the New Element Tape.

The Prologue section will precede the Generated Program in the Complete Program which simulates the system.

2.3.2 Epilogue

The Epilogue section is assigned the task of terminating the Generated Program into an acceptable program in machine translatable language. Included in the Epilogue section are such things as testing the computed results to determine if pre-assigned accuracy limits have been obtained, and transferring the program back to the Prologue section or to the Generated Program for further calculations. The function of the Epilogue section is to provide the Performance Simulator with the actual computer language statements which perform these functions.

The Epilogue section consists of all the statements immediately following the statement with the third (-) symbol encountered in column one of the New Element Tape up to and including the statement withthe first (+) symbol encountered in column one. The final statement in the Epilogue section must contain a (+) symbol in column one.

The Epilogue section will immediately follow the Generated Program in the Complete Program which simulates the system.

2.3.3 Calculations

The Calculations section gives the user the ability to supplement the capability of the Element Descriptions.

If for any reason a capability is difficult to implement into the Element Descriptor Library, then the Calculations section can be used to supplement the Element Descriptor Library with this capability. For example, suppose the user wishes to calculate the total power dissipated in a system. This would require a summation of the power dissipated in every element in the system. It would be most difficult to implement this capability into the Element Descriptor Library. In this case the Calculations section could be easily used to supplement the Element Descriptor Library with this capability.

The Calculations section must follow the Epilogue section in the New Element Tape. The declaration CALCULATIONS. (Abbreviation CL's) must precede the Calculations section. The declaration CALCULATIONS., which is located in columns 2 through 14, prepares the Performance Simulator to receive the Calculations section. The Calculations section is divided into two parts. The first part contains all the statements following the declaration CALCULATIONS. up to and including the statement with (-) symbol in column one. The second part contains all the remaining statements in the Calculations section. The last statement in the Calculations section must contain the (+) symbol in column one.

2.3.4 Special Indicators

The statements in the New Element Tape are given in standard MAD format except the symbols (-), (+), and (⊕) which are used as special indicators for the Performance Simulator.

2.3.4.1 The Meaning and Use of the (-) Symbol When Located in Column One of the New Element Tape

There are four (-) symbols located in column one in the New Element Tape. The first (-) symbol encountered in column one of the New Element Tape indicates where the first part of the Calculations section will be located in the Complete Program. The first part of the Calculations section immediately follows the statement which contains the first (-) symbol in column one.

The second (-) symbol encountered in column one indicates where the second part of the Calculations section will be located in the Complete Program. The second part of the Calculations section immediately follows the statement which contains the second (-) symbol in column one.

The third (-) symbol encountered in column one of the New Element Tape indicates where the Generated Program will be located in the Complete Program. The Generated Program immediately follows the statement which contains the third (-) symbol in column one.

The fourth (-) symbol is located in column one of the Calculations section. This symbol identifies the first and second parts of the Calculations section. The first part includes all the statements following the declaration CALCULATIONS. through and including the statement which contains the (-) symbol. The second part includes all the remaining statements in the Calculations section. The final statement in the Calculations section must contain a (+) symbol in column one.

2.3.4.2 The Meaning and Use of the (+) Symbol When Located in Column One Of The New Element Tape

There are two (+) symbols located in column one in the New Element Tape. The first (+) symbol must appear in column one of the last statement in the Epilogue section. The second (+) symbol must appear in column one of the last statement in the Calculations section.

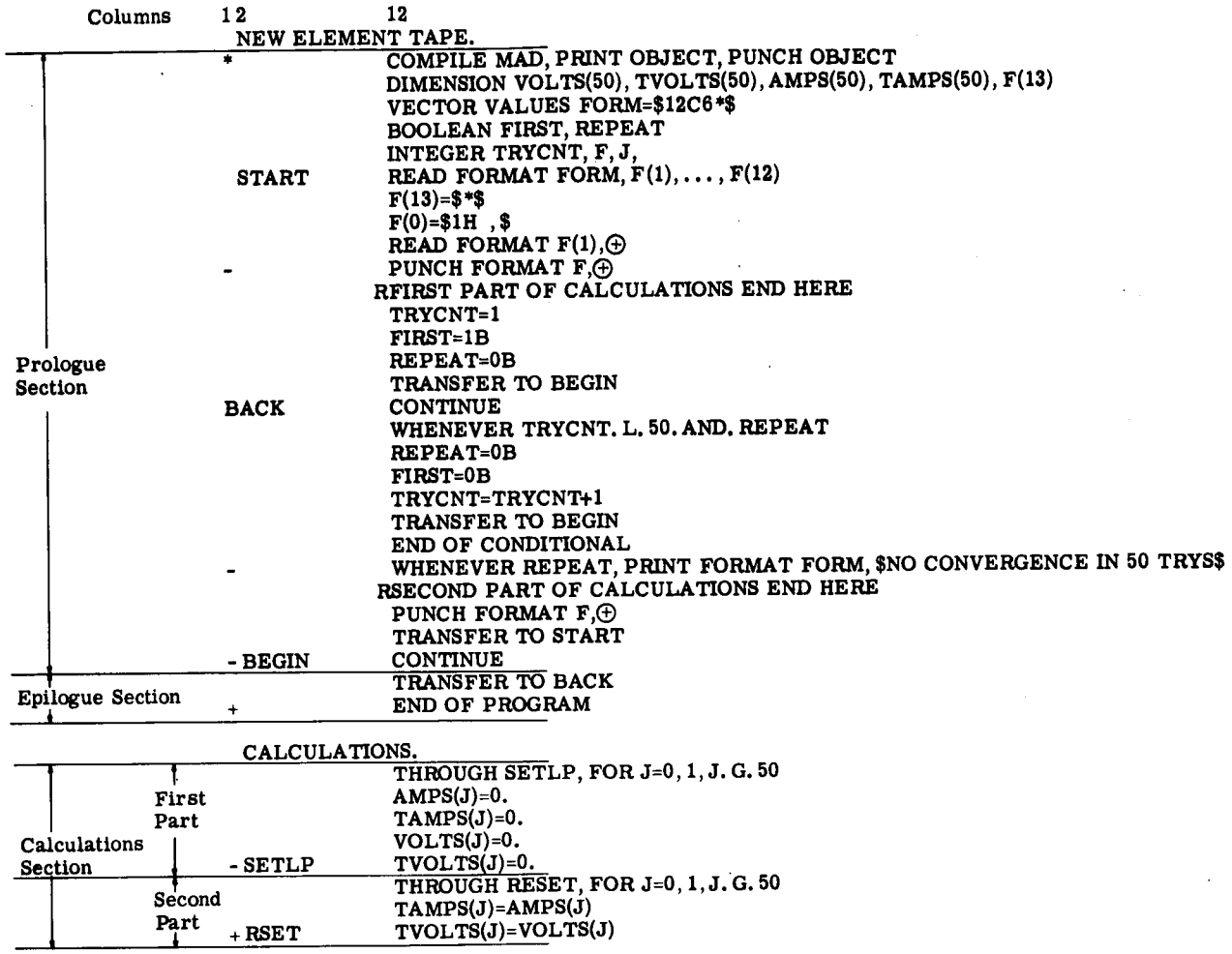
2.3.4.3 Meaning and Use of the (⊕) Symbol When Located in The New Element Tape

When the ⊕ symbol is encountered for the first time in the New Element Tape, a list of MAD names which correspond to the Input parameters is punched on cards and inserted at the place where ⊕ symbol was first encountered.

The second ⊕ symbol encountered causes the same list to be punched out again. This policy was adapted so that the Input Parameters could be printed out immediately after they are read in for verification.

The third and final ⊕ symbol encountered causes a list of the Desired Results to be punched so that the results may be printed through the use of a PRINT FORMAT MAD statement.

Example of New Element Tape



3 ELEMENT DESCRIPTOR LIBRARY

In order to simulate a physical system, the Performance Simulator must have available information concerning the physical laws or relationships for each element in the system. This information is contained in the Element Descriptor Library. The Element Descriptor Library is composed of Element Descriptions. Each Element Description describes the characteristics of a particular element to the Performance Simulator.

3.1 ELEMENT DESCRIPTION

The information which defines the physical laws or relationships of an element is communicated to the Performance Simulator by an Element Description.

An Element Description consists of the following information which must appear in the given order.

3.1.1 ELEMENT DESCRIPTION. Declaration (Abbreviation EL'N)

The declaration ELEMENT DESCRIPTION. is the first statement in the Element Description. This declaration prepares the Performance Simulator to receive the Element Description.

The declaration ELEMENT DESCRIPTION. will be located in columns 2 through 21.

3.1.2 NAME OF ELEMENT Assertion (Abbreviation NM'T)

The assertion NAME OF ELEMENT = followed by the Element Name is the second statement in the Element Description. Rules governing the choice of Element Names have been given previously.

The assertion NAME OF ELEMENT = should be located starting in column 2.

Examples Illustrating Element Name Assertion

Columns	1	2
		NAME OF ELEMENT = RES
		NAME OF ELEMENT = BATT
		NAME OF ELEMENT = AMPL

3.1.3 ATTACHMENT NAMES Assertion (Abbreviation AT's)

The assertion ATTACHMENT NAMES = followed by the Attachment Names, which are separated by commas, is the third statement in the Element Description. Rules governing the choice of the Attachment Names have been given previously.

The assertion ATTACHMENT NAMES = should be located in columns 2 through 72. Continuation to additional cards is allowed. Continuation cards should use columns 21 through 72.

Examples Illustrating Attachment Names Assertions

Columns	1	2 21
		ATTACHMENT NAMES = GRID, PLATE, CATH
		ATTACHMENT NAMES = 1, 2
		ATTACHMENT NAMES = INPUT, OUTPUT

3.1.4 BROAD SCOPE PARAMETERS Assertion (Abbreviation BR's)

A Broad Scope Parameter is a parameter whose value is the same at all attachment branches of an attachment. Some examples of Broad Scope Parameters are: volts, pressure, and displacement. Once a parameter has been declared Broad Scope in any Element Description, it must be declared Broad Scope in all Element Descriptions where this parameter occurs.

A Narrow Scope Parameter is a parameter whose value is not necessarily the same at all attachment branches of an attachment. Some examples of Narrow Scope Parameters are: current, flow, and force.

The Performance Simulator assumes all parameters to be Narrow Scope unless they are declared Broad Scope.

The assertion BROAD SCOPE PARAMETERS = followed by the Broad Scope Parameters, which are separated by commas, is the fourth statement in the Element Description. Rules governing the choice of the Parameter Names have been given previously.

The assertion BROAD SCOPE PARAMETERS = should be located in columns 2 through 72. Continuation to additional cards is allowed. Continuation cards should use columns 27 through 72.

Examples Illustrating Broad Scope Parameter Assertion

Columns	1	2	27
		BROAD SCOPE PARAMETERS =	VOLTS, OHMS
		BROAD SCOPE PARAMETERS =	PRES

3.1.5 Statement Collection

A Statement Collection communicates a specific physical law or relationship of an element to the Performance Simulator. The complete description of these physical laws or relationships for a particular element may contain many Statement Collections. The ordering of these Statement Collections is arbitrary.

The Statement Collection consists of the following information which must appear in the given order.

3.1.5.1 STATEMENT COLLECTION. Declaration (Abbreviation ST'N)

The declaration STATEMENT COLLECTION. is the first statement in the Statement Collection. This declaration prepares the Performance Simulator to receive the Statement Collection.

The declaration STATEMENT COLLECTION. will be located in columns 2 through 22.

3.1.5.2 Capability Statement

The Capability Statement is the second statement in the Statement Collection. The Capability Statement conveys to the Performance Simulator what parameters are necessary in order to calculate other parameters. All Capability Statements will be located starting in column 5.

The Capability Statements add the following special words to the Performance Simulator language:

a. THEN
b. ESTIMATE
c. COMPUTE
d. WITHOUT

THEN Capability Statement

The word THEN set off by commas separates and identifies the "If Known" Parameters from the Calculable Parameters in the Capability Statement. The "If Known" Parameters are located to the left of the word THEN and

the Calculable Parameters are located to the right. The "If Known" Parameters of the Capability Statement are specified by a series of parameters each followed by an Attachment Name in parentheses. These "If Known" Parameters must be separated by commas. The Calculable Parameters are specified by a series of parameters each followed by an Attachment Name and if necessary an Attachment Branch Identifier in parentheses. These Calculable Parameters must be separated by commas. The Attachment Branch Identifier is used if and only if the Calculable Parameter is Narrow Scope. This Attachment Branch Identifier in the Calculable Parameters implies the attachment branch currently being considered.

Examples Illustrating THEN Capability Statement

Suppose the user wishes to implement into the Element Description for an amplifier the capability of determining the output voltage of an amplifier if the input voltage and amplification factor are known. Also assume VOLTS has been declared Broad Scope. In this case

Columns	5
	VOLTS(INPUT), AMPLF, THEN, VOLTS(OUTPUT)

would be an appropriate Capability Statement, where AMPLF represents amplification factor.

Suppose the user wishes to implement into the Element Description for a resistor, whose Attachment Names are 1 and 2, the capability of determining the current at attachment 1 when the voltages at attachments 1 and 2 and the resistance, which is specified at attachment 1, are known. In this case

Columns	5
	OHMS(1), VOLTS(1), VOLTS(2), THEN, AMPS(1, A)

would be the appropriate Capability Statement. Since AMPS is Narrow Scope, the Attachment Branch Identifier A is used to imply the attachment branch presently being considered.

ESTIMATE Capability Statement (Abbreviation ES'E)

Often physical systems are simulated most conveniently through iterative techniques. That is, the program is so constructed that an initial estimate is improved by repeated calculations. The ESTIMATE capability is useful

only if there exists another independent method, in the Element Descriptor Library, to calculate the desired parameter. The word ESTIMATE followed by a comma and the parameter to be estimated conveys to the Performance Simulator that the method of solution is an iteration technique.

Again an example would serve to illustrate the ESTIMATE capability. Suppose the user wishes to convey to the Performance Simulator the Capability of the iterative approach to the solution for the output voltage of the amplifier. In this case

Columns	5
	ESTIMATE, VOLTS(OUTPUT)

would be an appropriate Capability Statement.

COMPUTE Capability Statement (Abbreviation CM'E)

Often it is useful to have a Capability Statement that requires no "If Known" Parameters to yield the Calculational Parameters. The word COMPUTE followed by a comma which is followed by the Calculable Parameters gives this capability to the user. For example, suppose the user wishes to convey to the Performance Simulator the capability for determining the weight of a resistor. Suppose the weight is associated with the attachment labeled 1. In this case

Columns	5
	COMPUTE, WEIGHT(1)

would be the appropriate Capability Statement. Following this Capability Statement the user must either supply a method to calculate the weight or transfer to an appropriate subroutine where this information is given.

WITHOUT Capability Statement (Abbreviation WT'T)

In order to allow a generic element name to be applied to a fairly wide class of elements -- some of which may not have all of the attachments possessed by others -- the WITHOUT statement is used. In this way, only those statement collections which fit a given element will be used in the simulation.

For example, suppose that the user wants to use the name HMOTOR for hydraulic motors that have an attachment SHAFT. Some HMOTOR elements may also have a power take-off attachment (PTO). If it were not possible to indicate those descriptions which are valid on HMOTOR elements that do not have PTO attachments, two separate elements would be required. To indicate this situation one writes in this case

Columns	5
	PRESS (INLET), WITHOUT (PTO), THEN, TORQUE (SHAFT)

3.1.5.3 Calculational Statements

Immediately following each Capability Statement the user must supply the program statements which will yield the Calculable Parameters given the "If Known" Parameters listed in the Capability Statement. These statements must be written in Michigan Algorithmic Decoder language (MAD language), except as modified by the ⊕ and ⊖ symbols which convey special meaning to the Performance Simulator.

Meaning and Use of the Symbol ⊕

The ⊕ symbol is used in general to delimit the parameter, Attachment Name, and/or Attachment Branch Identifier for which the Performance Simulator must generate a unique system variable name of six or less alphanumeric characters.

The ⊕ symbol implies different procedures depending upon the preceding Capability Statement. There are three special cases.

Case 1.

If a particular Attachment Name is located only on the left side of the word THEN in the Capability Statement, the statement ⊕ Para. (A.N., I) ⊕ in the calculational statements implies a summation of the parameter values over all branches of the attachment. The Attachment Branch Identifier (I) following the Attachment Name has no significance in itself. Other letters may be used if desired.

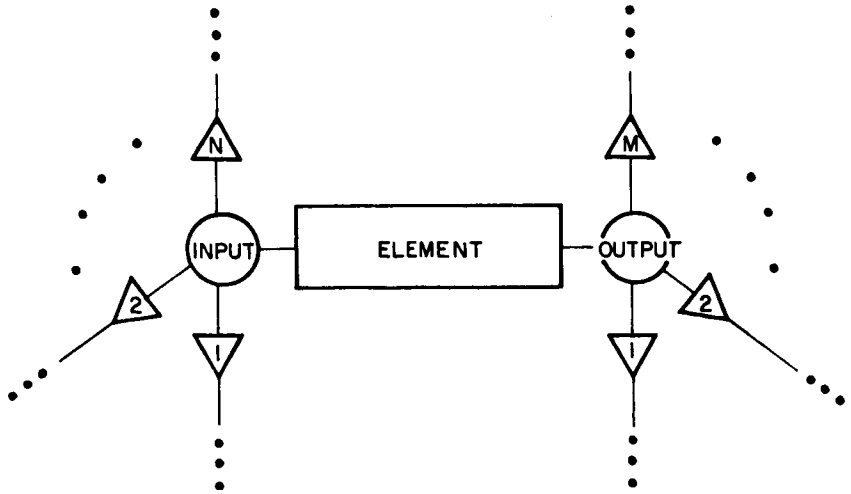
Case 2.

The statement ⊕ Para. (A.N.) ⊕ in the calculational statements implies the substitution of the parameter value in the attachment branch presently being considered.

Case 3.

If a particular Attachment Name is located on both sides of the word THEN in the Capability Statement, the statement ⊕ Para. (A. N., I) ⊕ implies a summation of the parameter values over all branches of the attachment except the attachment branch presently being considered.

General Example



Suppose the user wishes to indicate the capability and calculational procedure to compute the AMPS in the attachment branch presently being considered at the INPUT attachment if the AMPS of all remaining attachment branches at both the INPUT and OUTPUT attachments are known.

In this case the following Statement Collection would be appropriate.

Columns	2	5	12
	STA	TEMENT	COLLECTION.
Capability Statement		AMPS(INP	UT), AMPS(OUTPUT), THEN, AMPS(INPUT, A)
Calculational Statements			T = 0.
			T = T + ⊕AMPS(OUTPUT, A) ⊕
			S = 0.
			S = S + ⊕AMPS(INPUT, I) ⊕
			⊕AMPS(INPUT) ⊕= T - S

Since the attachment OUTPUT is located only on the left side of the word THEN in the Capability Statement, the statement ⊕AMPS(OUTPUT, A) ⊕ implies a summation of AMPS in each attachment branch of the OUTPUT attachment. Therefore the following statements:

T = 0.

T = T + ⊕AMPS(OUTPUT, A) ⊕

sum the AMPS for all of the OUTPUT attachment branches. The letter A carries no meaning in itself. Any six or less alphanumeric character word could have been used.

Since the attachment INPUT is located on both sides of the word THEN in the Capability Statement, ⊕AMPS(INPUT, I) ⊕ implies a summation of AMPS in each attachment branch of the INPUT attachment except the attachment branch presently being considered. Therefore the following statements:

S = 0.

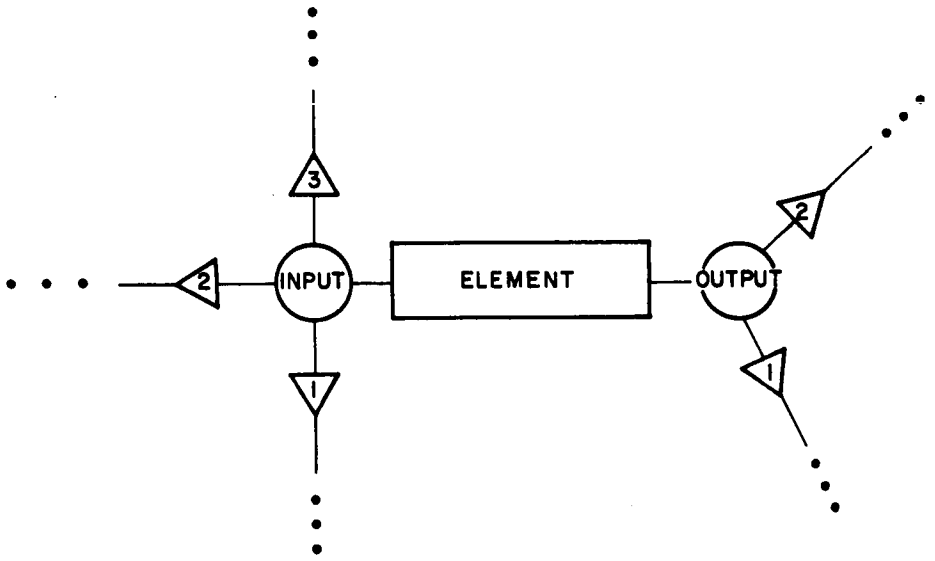
S = S + ⊕AMPS(INPUT, I) ⊕

sum the AMPS at all the INPUT attachments except for the AMPS in the attachment branch presently being considered. Again the letter I carries no meaning in itself.

The statement ⊕AMPS(INPUT)⊕ implies the value of AMPS in the attachment branch presently being considered.

The final statement in the Statement Collection indicates that the value of AMPS in the attachment branch presently being considered at the INPUT attachment equals the difference between the summation of the AMPS over all attachment branches at the OUTPUT attachment and the summation of the AMPS over all attachment branches at the INPUT attachment except the attachment branch presently being considered.

Particular Example



Consider how the following Statement Collection, which was used in the general example above, would be used to compute AMPS at Attachment Branch Identifier 2 of the INPUT attachment.

Columns	2	5	12
	STA	TEMENT	COLLECTION.
Capability Statement		AMPS(INP	UT), AMPS(OUTPUT), THEN, AMPS(INPUT, A)
Calculational Statements			T = 0.
			T = T + ⊕AMPS(OUTPUT, A) ⊕
			S = 0.
			S = S + ⊕AMPS(INPUT, I) ⊕
			⊕AMPS(INPUT) ⊕= T - S

The form of the calculational statements that would be generated by the Performance Simulator for the particular problem under consideration is as follows:

```
T = 0.

T = T +AMPS(OUTPUT, 1)

T = T +AMPS(OUTPUT, 2)

S = 0.

S = S +AMPS(INPUT, 1)

S = S +AMPS(INPUT, 3)

AMPS(INPUT, 2) = T - S
```

The final statement indicates that

```
AMPS(INPUT, 2) = AMPS(OUTPUT, 1) + AMPS(OUTPUT, 2) - (AMPS(INPUT, 1) - AMPS(INPUT, 3))
```

Meaning and Use Of The ⊖ Symbol

The ⊖ symbol is used to delimit Function Substitutions and Floating Statement Labels.

The ⊖ symbol is used to delimit the statements which are to be modified by Function Substitution Statements. The statement which is enclosed by ⊖ symbols will be modified when the Generated Program is formulated. The reader is referred to Section 4.1 for complete discussion of the ⊖ symbol in conjunction with Function Substitution Statements.

The Floating Statement Label allows the use of Statement Labels in Statement Collections. Since an element may appear any number of times in a system, the same Statement Collections might therefore occur any number of times in a program, which simulates the system. To avoid ambiguity, the user must not use fixed Statement Labels within a Statement Collection.

Floating Statement Labels allow the Performance Simulator to generate unique Statement Labels and thus eliminate any ambiguity in labels.

The user wishing to use a Floating Statement Label writes:

⊖ **XXXXXX ⊖

where the X's represents any six or less alphanumeric character Statement Label which the user may care to use in his Statement Collection. The floating statement label is initiated by the ⊖ symbol followed by two asterisks (*) and is closed by the ⊖ . The Performance Simulator will generate a unique Statement Label and replace the entire Floating Statement Label by this unique label. Should the Statement Collection appear again in the program, another unique Statement Label would be generated and substituted for the Floating Statement Label.

3.1.5.4 End of Statement Collection Declarations

Each Statement Collection is terminated by another STATEMENT COLLECTION. declaration or by the DESCRIPTION FINISHED. declaration. These declarations convey the end of the Statement Collection to the Performance Simulator.

3.1.6 DESCRIPTION FINISHED. Declaration (Abbreviation DS'D)

The final statement in an Element Description must be the declaration DESCRIPTION FINISHED.. The declaration DESCRIPTION FINISHED,, which is located in columns 2 through 22, conveys the end of the Element Description to the Performance Simulator.

4 UTILITY DECLARATIONS

Utility declarations are additional features which are not necessarily essential to the Performance Simulator. These features allow the Performance Simulator to produce better programs in some cases and to produce programs more easily in others.

4.1 FUNCTION SUBSTITUTIONS (Abbreviation FN's)

Function Substitutions allows modification of any six or less alphanumeric word which is enclosed by the ⊖ symbols at the time the Generated Program is formulated. This modification is implemented by Function Substitution Statements which must be preceded by the declaration FUNCTION SUBSTITUTIONS.

4.1.1 FUNCTION SUBSTITUTIONS. Declaration

The declaration FUNCTION SUBSTITUTIONS. must precede the Function Substitution Statements. The declaration FUNCTION SUBSTITUTIONS., which is located in columns 2 through 23, prepares the Performance Simulator to receive the Function Substitution Statements.

4.1.2 Function Substitution Statements

The Function Substitution Statements convey the modifications that are to be made and the scope of these modifications to the Performance Simulator. Any six or less alpha-numeric character word may be substituted for any other word which is enclosed in ⊖ symbols.

The form of the Function Substitution Statements is defined as follows:

Let OLDWRD — represent any general six or less alphanumeric word which is enclosed by the ⊖ symbols.

Let NUWORD — represent any general six or less alpha-numeric word which is to be substituted where the ⊖ symbols occur.

The the allowable Function Substitution Statements are:

NUWORD, OLDWRD(E. N. , E. I)

NUWORD, OLDWRD(E. N.)

NUWORD, OLDWRD

The effect of these statements is to replace OLDWRD, when set off by the ⊖ symbols, by NUWORD.

The scope of the substitution is controlled as follows:

a. The Function Substitution Statement NUWORD, OLDWRD(E. N. , E. I.) implies that a substitution will take place only for the element with the particular Element Name and Identifier.

b. The Function Substitution Statement NUWORD, OLDWRD(E. N.) implies that a substitution will take place for all the elements with the given Element Name.

c. The Function Substitution Statement NUWORD, OLDWRD implies a substitution will occur for any occurrance of OLDWRD which is set off by ⊖ symbols.

If the Function Substitution Statement is not given, the original OLDWRD enclosed in ⊖ symbols will be used.

The best way to illustrate the use of ⊖ symbol in conjunction with Function Substitution is by way of an example. Suppose the user wishes to represent the resistance of a resistor as a function of temperature. Also, assume each resistor has a different functional relationship with respect to temperature and, for example purposes assume there are three resistors in the system.

Consider a particular Statement Collection in the Element Description of a resistor, and see how this capability could be introduced.

Columns	2	5	12
	STA	TEMENT	COLLECTION.
		OHMS(1),	VOLTS(1), AMPS(2), THEN, VOLTS(2)
			T = 0.
			T = T + ⊕ AMPS(2, A) ⊕
			⊕ OHMS(1) ⊕ = ⊖ OHMS(1) ⊖ . (TEMP)
			⊕ VOLTS(2) ⊕ = ⊕ VOLTS(1) ⊕ -(T+ ⊕ AMPS(2) ⊕)* ⊕ OHMS(1) ⊕

The statement ⊕OHMS(1) ⊕ = ⊖ OHMS(1) ⊖ . (TEMP) instructs the Performance Simulator to go to the Function Substitution Statements and find the name of the subroutine that will be used to calculate the value of the resistance which is a function of temperature.

Consider the Functional Substitution Statements needed to complete this capability.

Columns	1	2	5
		FUNCTIONS SUBSTITUTION.	
			SUBRT1, OHMS(RES, 1)
			SUBRT2, OHMS(RES, 2)
			SUBRT3, OHMS(RES, 3)

SUBRT1, SUBRT2, and SUBRT3 are the names of the subroutines which must be given to express resistance as a function of temperature for each particular resistor in the system.

4.2 EQUIVALENCE (Abbreviation EQ'E)

Often it is desirable to know the exact name that will be assigned by the Performance Simulator to a parameter at a specific point in a system. For example, suppose the user wishes to instruct the Performance Simulator to print out the Desired Results for verification. In this case all the Desired Results would be made equivalent to known names. The user would then instruct the Performance Simulator to print out the known names. This Equivalence capability is implemented by Equivalence Statements which are preceded by the declaration EQUIVALENCE. .

4.2.1 EQUIVALENCE. Declaration

The declaration EQUIVALENCE. must precede the Equivalence Statements. The declaration EQUIVALENCE., which is located in columns 2 through 13, prepares the Performance Simulator to receive the Equivalence Statements.

4.2.2 Equivalence Statements

Equivalence Statements conveys the specific equivalence to the Performance Simulator.

A general Equivalence Statement has the following form:

Equivalence Name = Parameter(Attachment Branch Address)

The Equivalence Name must be six or less alpha-numeric characters. No restrictions are placed on the choice or ordering of these characters.

A specific example might be:

Columns	1	2	5
		EQUIVALENCE.	
			PWR = POWER(RES, 1(1,A))

The above statement equates PWR to the name given by the Performance Simulator to the parameter POWER at the particular attachment branch in the system given by the Attachment Branch Address RES, 1(1, A).

4.3 DIAGNOSTIC AIDS

To assist the user in obtaining successful simulator runs, several diagnostic aids are available.

4.3.1 CHECKOUT. (Abbreviation CH'T) and CHECKRUN. (Abbreviation CH'N). Declarations

The declarations CHECKOUT and CHECKRUN are equivalent in that each activates the same set of diagnostic printing during a performance simulator run. The two forms are available in order to allow the user to employ whichever form occurs more naturally to him.

5 PERFORMANCE SIMULATOR LOGIC

The logic used by the Performance Simulator in the generation of a program, which will simulate the system, is the reverse of the usual logic used by humans. The usual human approach is a search that proceeds from the given information to the requested results. This approach could be used by the Performance Simulator but because of storage limitations is impractical. The storage difficulty arises because the Performance Simulator has no way of knowing when a method is necessary to the program which will yield the requested results. The Performance Simulator would be forced to enumerate every method available from the given information to the requested results. If the problem is well posed, this logic will eventually yield a program that will simulate the system. However, this logic constitutes an exhaustive search with only a small fraction of the enumerated methods used in the program, which will yield the requested results in terms of the given information.

In order to eliminate this exhaustive search, the logic used by the Performance Simulator proceeds from the requested results to the given information. In this way every step generated is necessarily essential to the program except when the Performance Simulator gets to a point where the program cannot be extended to yield the requested results. When this occurs, the Performance Simulator will regress to a point where a choice was made in the method used and will make a different choice and again try to produce a program that will yield the requested results. This logic minimizes the number of unnecessary steps.

The program generated by this logic is backward in that the first Statement Collection specified is the last one needed and so on throughout all the Statement Collections.

5.1 DISCUSSION OF PERFORMANCE SIMULATOR LOGIC

The following is a step by step detailed discussion of the Performance Simulator Logic.

Step 1. The Performance Simulator will first search each attachment branch in the system for parameters which have been requested by the Desired Result Statements. (If no requested Desired Results can be found, the problem is trivial.)

Step 2. Whenever an attachment branch is found where there are requested parameters, steps must be taken to satisfy these requests.

2A. The requested parameters may all be Input Parameters. (If this is true, the program is complete.)

Step 3. Whenever a requested parameter is found which is not an Input Parameter, steps must be taken to satisfy these requests.

3A. The Performance Simulator will collect all the Statement Collections that are pertinent to obtain the requested parameter in the Element Descriptor Library for the two elements that occur at the attachment branch where the results are requested.

3B. The Performance Simulator will check each pertinent Statement Collection to determine its effectiveness. The effectiveness factor is based upon the number of requested parameters which are not Input Parameters.

Step 4. A requested parameter will be eliminated if there exist a statement Collection, which will yield the requested parameter, in the Element Descriptor Library.

4A. If one or more Statement Collections are available, the Performance Simulator will choose one based upon its effectiveness and will indicate the number of choices available. The chosen Statement Collection will generally make a request for new requested parameters. The Performance Simulator logic will then transfer back to Step 2 and continue.

4B. If the Element Descriptor Library does not contain a Statement Collection which will yield the requested parameter, the program is "non-extendable". When this occurs, the Performance Simulator will check to determine if any previous choices were made.

4C. There may have been no previous choices. (In this case the problem is not well posed.)

4D. There may have been one or more previous choices. In this case the Performance Simulator will regress to the first previous step where a choice was made, and will choose a different Statement Collection. This Statement Collection will generally make a request for new requested parameters. The Performance Simulator Logic will then transfer back to Step 2 and continue.

Step 5. The above search is repeated until Step 2A is satisfied, or until the problem is shown to be not well posed, or until the requested parameters have been requested twice. If the requested results have been requested twice and if the program generated is not trivial, the Performance Simulator will choose the Statement Collections with the estimate capability to produce an iterative program which will simulate the system.

The following Performance Simulator Logic Diagram (Figure A-1) illustrates the logic which is used by the Performance Simulator in formulating the Generated Program.

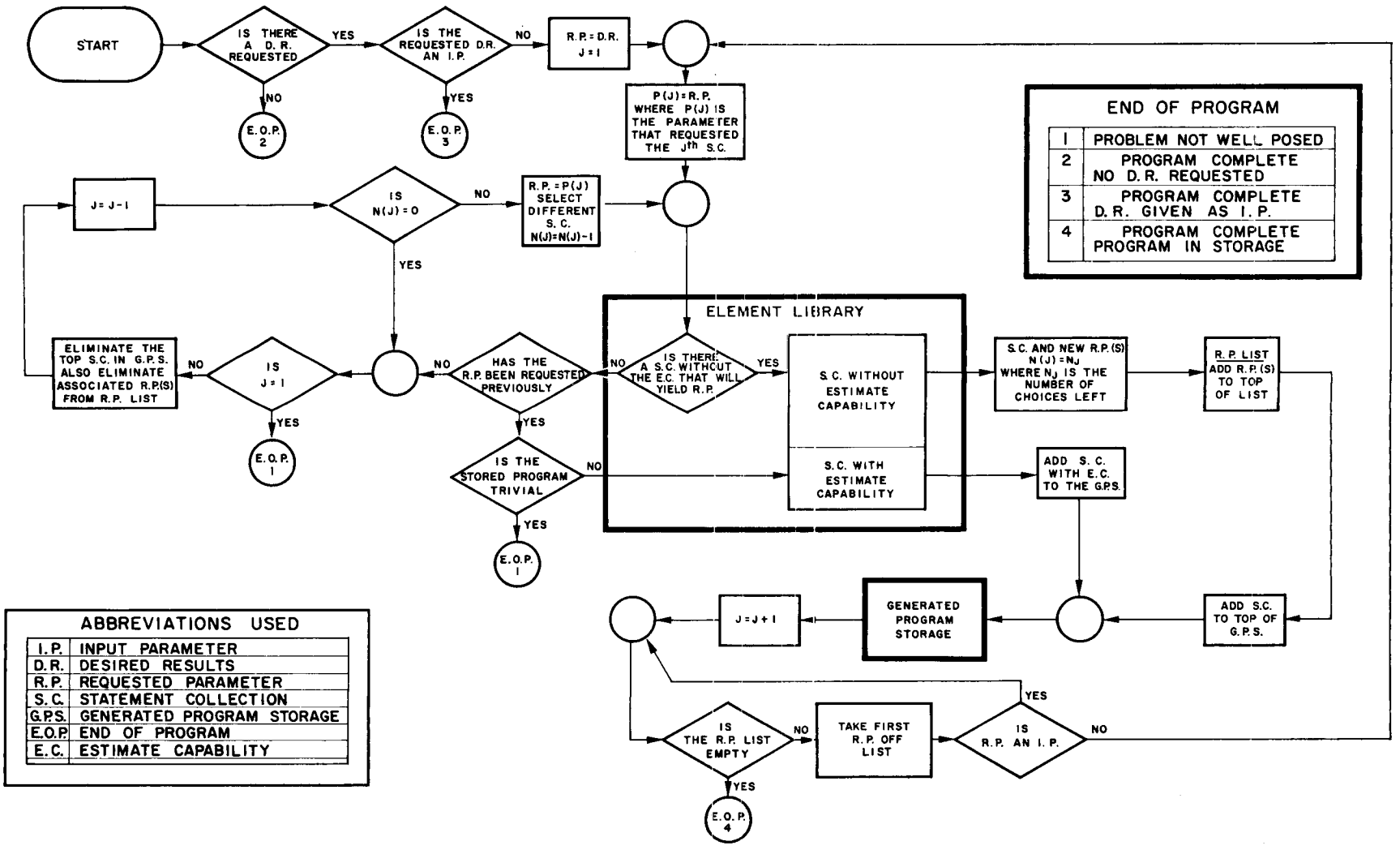


Figure A-1. Performance Simulator Logic Diagram

6 PERFORMANCE SIMULATOR SYSTEM DIAGRAMMING

In order to diagram a system in a manner which is easily associated with the logic of the simulator, the following conventions will be used:

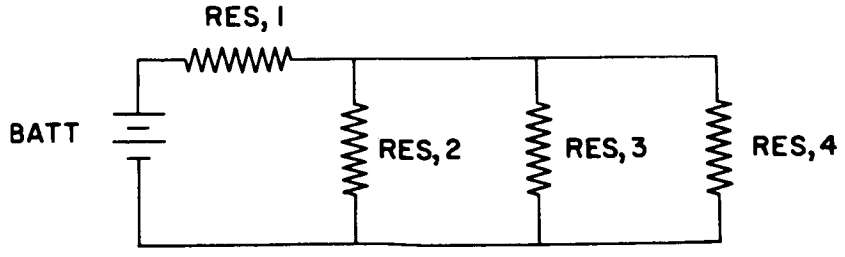
a. An Attachment is any unique, specified point of an element where Input Parameters, Desired Results, and/or Connections are specified. When forming the system diagram, attachments are denoted by the symbol ◯ .

b. When an attachment has more than one attachment branch, Attachment Branch Identifiers must be used. When forming the system diagram, Attachment Branch Identifiers are enclosed by the symbol ▷ where the apex is oriented away from the identified attachment branch.

c. The symbol ◇ is used to show the connection of one attachment to another. The symbol ◇ is associated with storage location in the computer. This storage location contains all the parameters of the two attachments which are connected by the ◇ symbol. To avoid ambiguity, no two attachments, which specify the same parameters, can be connected.

Examples Illustrating the Above Symbols

Suppose one wants to form the System Diagram for the following network using the above symbols.



In this case the following System Diagrams would be appropriate.

DIAGRAM 1

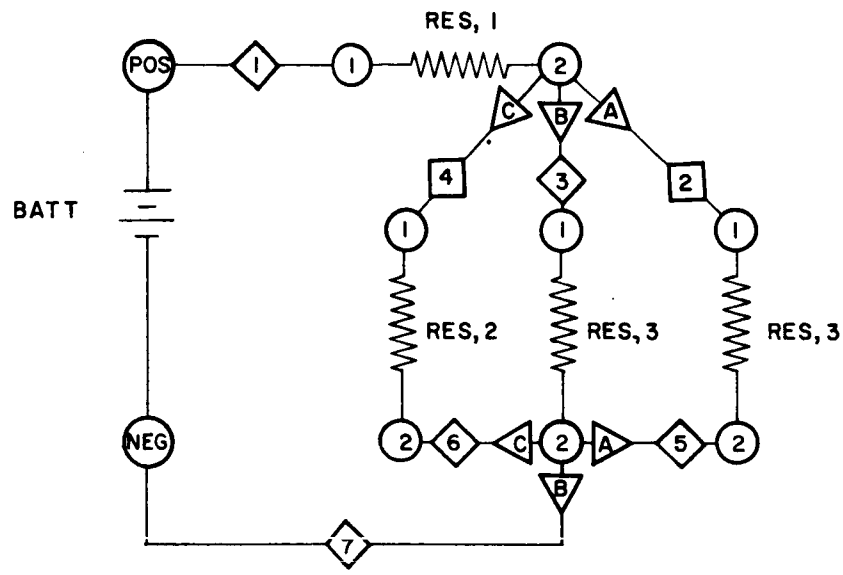
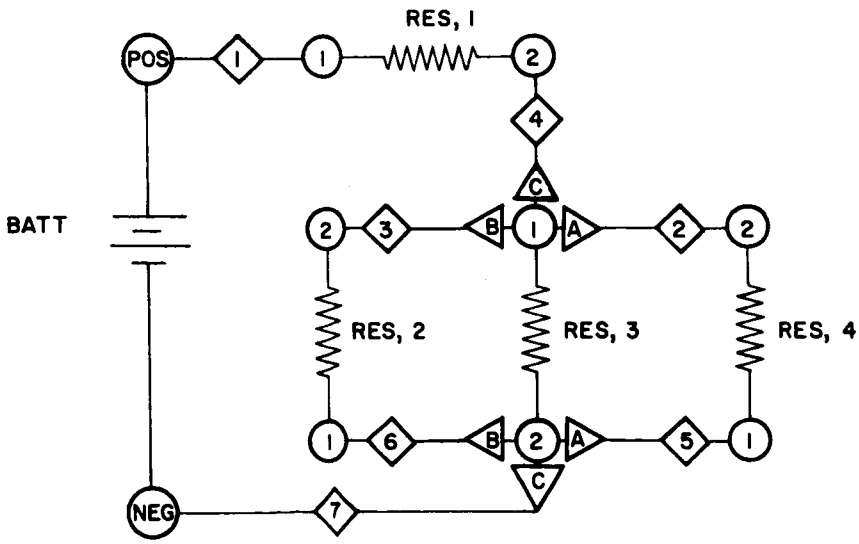


DIAGRAM 2



NOTE: There usually exists more than one satisfactory system diagram for any given system.

7 COMPLETE EXAMPLE

To illustrate the technique used by the Performance Simulator a simple example is completely solved using the Performance Simulator logic. The example is intended to illustrate the following:

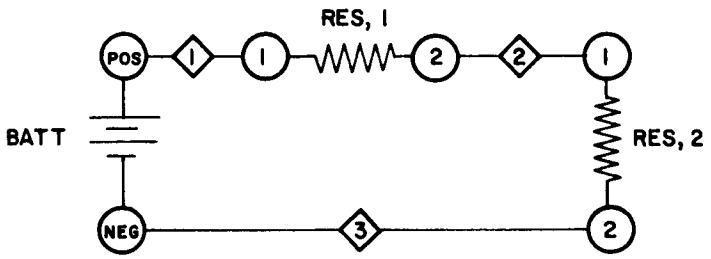
a. What information is required by the Performance Simulator.

b. How this information is presented to the Performance Simulator.

c. The logic used by the Performance Simulator in generating the Complete Program that can be used to simulate the system.

The example, which in no way measures the capability offered by the Performance Simulator, was chosen to be simple so that the rules and logic associated with the Performance Simulator are not hidden by complexity. The reader is assumed to be a person who is generally familiar with the Performance Simulator rules and logic which are given previously.

7.1 PROBLEM CONSIDERED



Suppose the user wishes to use the Performance Simulator to produce a computer program for determining the current at attachment 1 of resistor 2 in the above circuit when given the following Input Parameters:

VOLTS(BATT(NEG))	The specified reference voltage at the negative terminal of the battery
OCV(BATT(NEG))	The open circuit voltage of the battery
OHMS(BATT(NEG))	The internal resistance of the battery
OHMS(RES, 1(1))	The resistance of resistor 1
OHMS(RES, 2(1))	The resistance of resistor 2

7.2 SOURCE PROGRAM

The user's first task is to supply a Source Program to the Performance Simulator. The Source Program consists of the following information:

a. System Description (Connection Statements)
b. Input Parameters
c. Desired Results
d. New Element Tape

The rules for presenting the above information have been given previously.

```
      CONNECTIONS.
         BATT(POS).TO.RES.1(1)
         RES.1(2).TO.RES.2(1)
         RES.2(2).TO.BATT(NEG)

      INPUT PARAMETERS.
         VOLTS(BATT(NEG))
         OCV(BATT(NEG))
         OHMS(BATT(NEG))
         OHMS(RES.1(1))
         OHMS(RES.2(1))

      DESIRED RESULTS.
         AMPS(RES.2(1))

      NEW ELEMENT TAPE.
     *          COMPILE MAD.PRINT OBJECT.PUNCH OBJECT
               DIMENSION VOLTS(50).TVOLTS(50).AMPS(50).TAMPS(50).F(13)
               VECTOR VALUES FORM=$12C6*$
               BOOLEAN FIRST.REPEAT
               INTEGER TRYCNT.F.J
     START     READ FORMAT FORM.F(1)....F(12)
               F(13)=$*$
               F(0)=$1H .$
               READ FORMAT F(1).0
     -         PUNCH FORMAT F.0
              RFIRST PART OF CALCULATIONS END HERE
               TRYCNT=1
               FIRST=1B
               REPEAT=0B
               TRANSFER TO BEGIN
     BACK      CONTINUE
               WHENEVER TRYCNT.L.50.AND.REPEAT
               REPEAT=0B
               FIRST=0B
               TRYCNT=TRYCNT+1
               TRANSFER TO BEGIN
               END OF CONDITIONAL
     -         WHENEVER REPEAT.PRINT FORMAT FORM.$NO CONVERGENCE IN 50 TRYS$
              RSECOND PART OF CALCULATIONS END HERE
               PUNCH FORMAT F.0
               TRANSFER TO START
     -BEGIN    CONTINUE
               TRANSFER TO BACK
     +         END OF PROGRAM
```

```
      CALCULATIONS.
                THROUGH SETLP,FOR J=0,1,J.G.50
                AMPS(J)=0.
                TAMPS(J)=0.
                VOLTS(J)=0.
-SETLP          TVOLTS(J)=0.
                THROUGH RESET,FOR J=0,1,J.G.50
                TAMPS(J)=AMPS(J)
+RSET           TVOLTS(J)=VOLTS(J)
```

7.3 ELEMENT DESCRIPTOR LIBRARY

The Element Descriptor Library communicates the information concerning the physical laws or relationships for each element in the system to the Performance Simulator. The rules for presenting the above information have been given previously.

```
      ELEMENT DESCRIPTION.                                              0001D
      NAME OF ELEMENT = RES                                             0001N
      ATTACHMENT NAMES = 1,2                                            0001A
      BROAD SCOPE PARAMETERS = VOLTS,OHMS                               0001B
      STATEMENT COLLECTION.                                             0001C001
         AMPS(2),AMPS(1),THEN,AMPS(1,A)                                 0001C001
                T=0.                                                    0001C001
                T=T+@AMPS(1,A)@                                         0001C001
                S=0.                                                    0001C001
                S=S+@AMPS(2,A)@                                         0001C001
                @AMPS(1)@=S-T                                           0001C001
      STATEMENT COLLECTION.                                             0001C002
         AMPS(1),AMPS(2),THEN,AMPS(2,A)                                 0001C002
                T=0.                                                    0001C002
                T=T+@AMPS(2,A)@                                         0001C002
                S=0.                                                    0001C002
                S=S+@AMPS(1,A)@                                         0001C002
                @AMPS(2)@=S-T                                           0001C002
      STATEMENT COLLECTION.                                             0001C003
         OHMS(1),AMPS(1),VOLTS(1),VOLTS(2),THEN,AMPS(1,A)               0001C003
                T=0.                                                    0001C003
                T=T+@AMPS(1,A)@                                         0001C003
                @AMPS(1)@=(@VOLTS(1)@-@VOLTS(2)@)/@OHMS(1)@-T           0001C003
      STATEMENT COLLECTION.                                             0001C004
         OHMS(1),AMPS(2),VOLTS(2),VOLTS(1),THEN,AMPS(2,A)               0001C004
                T=0.                                                    0001C004
                T=T+@AMPS(2,A)@                                         0001C004
                @AMPS(2)@=(@VOLTS(1)@-@VOLTS(2)@)/@OHMS(1)@-T           0001C004
      STATEMENT COLLECTION.                                             0001C005
         OHMS(1),AMPS(1),VOLTS(1),THEN,VOLTS(2)                         0001C005
                T=0.                                                    0001C005
                T=T+@AMPS(1,A)@                                         0001C005
                @VOLTS(2)@=@VOLTS(1)@-T*@OHMS(1)@                       0001C005
      STATEMENT COLLECTION.                                             0001C006
         OHMS(1),AMPS(2),VOLTS(2),THEN,VOLTS(1)                         0001C006
                T=0.                                                    0001C006
                T=T+@AMPS(2,A)@                                         0001C006
                @VOLTS(1)@=@VOLTS(2)@-T*@OHMS(1)@                       0001C006
      STATEMENT COLLECTION.                                             0001C007
         OHMS(1),VOLTS(1),AMPS(2),THEN,VOLTS(2)                         0001C007
                T=0.                                                    0001C007
                T=T+@AMPS(2,A)@                                         0001C007
                @VOLTS(2)@=@VOLTS(1)@-(T+@AMPS(2)@)*@OHMS(1)@           0001C007
      STATEMENT COLLECTION.                                             0001C008
         OHMS(1),VOLTS(2),AMPS(1),THEN,VOLTS(1)                         0001C008
                T=0.                                                    0001C008
                T=T+@AMPS(1,A)@                                         0001C008
                @VOLTS(1)@=@VOLTS(2)@-(T+@AMPS(1)@)*@OHMS(1)@           0001C008
```

```
STATEMENT COLLECTION.                                                    0001C009
   ESTIMATE AMPS(1)                                                      0001C009
            WHENEVER FIRST                                               0001C009
            REPEAT=1B                                                    0001C009
            @AMPS(1)@=@TAMPS(1)@                                         0001C009
            OTHERWISE                                                    0001C009
            @AMPS(1)@=ITTR.(@AMPS(1)@.@GAMPS(1)@.REPEAT)                 0001C009
            END OF CONDITIONAL                                           0001C009
            @GAMPS(1)@=@AMPS(1)@                                         0001C009
STATEMENT COLLECTION.                                                    0001C010
   ESTIMATE AMPS(2)                                                      0001C010
            WHENEVER FIRST                                               0001C010
            REPEAT=1B                                                    0001C010
            @AMPS(2)@=@TAMPS(2)@                                         0001C010
            OTHERWISE                                                    0001C010
            @AMPS(2)@=ITTR.(@AMPS(2)@.@GAMPS(2)@.REPEAT)                 0001C010
            END OF CONDITIONAL                                           0001C010
            @GAMPS(2)@=@AMPS(2)@                                         0001C010
STATEMENT COLLECTION.                                                    0001C011
   ESTIMATE VOLTS(2)                                                     0001C011
            WHENEVER FIRST                                               0001C011
            REPEAT=1B                                                    0001C011
            @VOLTS(2)@=@TVOLTS(2)@                                       0001C011
            OTHERWISE                                                    0001C011
            @VOLTS(2)@=ITTR.(@VOLTS(2)@.@GVOLTS(2)@.REPEAT)              0001C011
            END OF CONDITIONAL                                           0001C011
            @GVOLTS(2)@=@VOLTS(2)@                                       0001C011
STATEMENT COLLECTION.                                                    0001C012
   ESTIMATE VOLTS(1)                                                     0001C012
            WHENEVER FIRST                                               0001C012
            REPEAT=1B                                                    0001C012
            @VOLTS(1)@=@TVOLTS(1)@                                       0001C012
            OTHERWISE                                                    0001C012
            @VOLTS(1)@=ITTR.(@VOLTS(1)@.@GVOLTS(1)@.REPEAT)              0001C012
            END OF CONDITIONAL                                           0001C012
            @GVOLTS(1)@=@VOLTS(1)@                                       0001C012
DESCRIPTION FINISHED.                                                    0001F
ELEMENT DESCRIPTION.                                                     0002D
NAME OF ELEMENT = BATT                                                   0002N
ATTACHMENT NAMES = NEG.POS                                               0002A
BROAD SCOPE PARAMETERS = VOLTS.OHMS                                      0002B
STATEMENT COLLECTION.                                                    0002C001
   AMPS(NEG).THEN.AMPS(POS)                                              0002C001
            T=0.                                                         0002C001
            T=T+@AMPS(NEG.A)@                                            0002C001
            @AMPS(POS)@=T                                                0002C001
STATEMENT COLLECTION.                                                    0002C002
   AMPS(POS).THEN.AMPS(NEG)                                              0002C002
            T=0.                                                         0002C002
            T=T+@AMPS(POS.A)@                                            0002C002
            @AMPS(NEG)@=T                                                0002C002
STATEMENT COLLECTION.                                                    0002C003
   AMPS(NEG).VOLTS(NEG).OCV(NEG).OHMS(NEG).THEN.VOLTS(POS)               0002C003
            @VOLTS(POS)@=@VOLTS(NEG)@+@OCV(NEG)@-@AMPS(NEG)@*@OHMS(NEG)@ 0002C003
STATEMENT COLLECTION.                                                    0002C004
   AMPS(NEG).VOLTS(POS).OCV(NEG).OHMS(NEG).THEN.VOLTS(NEG)               0002C004
            @VOLTS(NEG)@=@VOLTS(POS)@-@OCV(NEG)@+@AMPS(NEG)@*@OHMS(NEG)@ 0002C004
STATEMENT COLLECTION.                                                    0002C005
   AMPS(NEG).VOLTS(NEG).VOLTS(POS).THEN.POWER(NEG)                       0002C005
            @POWER(NEG)@=(@VOLTS(NEG)@-@VOLTS(POS)@)*@AMPS(NEG)@        0002C005
DESCRIPTION FINISHED.                                                    0002F
```

7.4 GENERATED PROGRAM

The information given in the Source Program and Element Descriptor Library is sufficient for the Performance Simulator to formulate the Generated Program. By using the logic, which was discussed previously, the Performance Simulator will produce the following Generated Program:

This Generated Program is backward, in that, the first Statement Collection specified is the last one needed and so on throughout all Statement Collections. The Performance Simulator reverses this Generated Program when the Complete Program is formed.

The ◇ symbol is used to represent a connection in a system. The number which is located inside the ◇ symbol is associated with a particular connection in the system.

The numbers which are located at the right hand side of each statement in the Generated Program indicate the particular Statement Collection which was chosen by the Performance Simulator.

Generated Program

```
T=0.                                                        0001C003
AMPS ◇2 =(VOLTS ◇2 -VOLTS ◇3 )/OHMS ◇2 -T                   0001C003

T=0.                                                        0001C007
VOLTS ◇2 =VOLTS ◇1 -(T+AMPS ◇2 )*OHMS ◇1                    0001C007

VOLTS ◇1 =VOLTS ◇3 +OCV ◇3 -AMPS ◇3 *OHMS ◇3                0002C003

T=0.                                                        0002C002
T=T+AMPS ◇1                                                 0002C002
AMPS ◇3 =T                                                  0002C002

T=0.                                                        0001C001
S=0.                                                        0001C001
S=S+AMPS ◇2                                                 0001C001
AMPS ◇1 =S-T                                                0001C001

WHENEVER FIRST                                              0001C010
REPEAT=18                                                   0001C010
AMPS ◇2 =TAMPS ◇2                                           0001C010
OTHERWISE                                                   0001C010
AMPS ◇2 =ITTR.(AMPS ◇2 *GAMPS ◇2 ,REPEAT)                   0001C010
END OF CONDITIONAL                                          0001C010
GAMPS ◇2 =AMPS ◇2                                           0001C010
```

7.5 COMPLETE PROGRAM

The Complete Program is a computer program in machine translatable language that can be used to give numerical values of the Desired Results when the values of the Input Parameters are given. The Complete Program consists of the Generated Program and the New Element Tape. The Performance Simulator will reverse the Generated Program and insert it between the Prologue and Epilogue sections of the New Element Tape.

Complete Program

```
          COMPILE MAD,PRINT OBJECT,PUNCH OBJECT
          DIMENSION VOLTS(50),TVOLTS(50),AMPS(50),TAMPS(50),F(13)
          VECTOR VALUES FORM=$12C6*$
          BOOLEAN FIRST,REPEAT
          INTEGER TRYCNT,F,J
START     READ FORMAT FORM,F(1),...,F(12)
          F(13)=$*$
          F(0)=$1H ,$
          READ FORMAT F(1),0
          PUNCH FORMAT F,0
          THROUGH SETLP,FOR J=0,1,J.G.50
          AMPS(J)=0.
          TAMPS(J)=0.
          VOLTS(J)=0.
SETLP     TVOLTS(J)=0.
         RFIRST PART OF CALCULATIONS END HERE
          TRYCNT=1
          FIRST=1B
          REPEAT=0B
          TRANSFER TO BEGIN
BACK      CONTINUE
          WHENEVER TRYCNT.L.50.AND.REPEAT
          REPEAT=0B
          FIRST=0B
          TRYCNT=TRYCNT+1
          TRANSFER TO BEGIN
          END OF CONDITIONAL
          WHENEVER REPEAT,PRINT FORMAT FORM,$NO CONVERGENCE IN 50 TRYS$
          THROUGH RESET,FOR J=0,1,J.G.50
          TAMPS(J)=AMPS(J)
RSET      TVOLTS(J)=VOLTS(J)
         RSECOND PART OF CALCULATIONS END HERE
          PUNCH FORMAT F,0
          TRANSFER TO START
BEGIN     CONTINUE
          WHENEVER FIRST
          REPEAT=1B
          AMPS (2) =TAMPS (2)
          OTHERWISE
          AMPS (2) =ITTR.(AMPS (2) ,GAMPS (2) ,REPEAT)
          END OF CONDITIONAL
          GAMPS (2) =AMPS (2)
```

```
T=0.
S=0.
S=S+AMPS ②
AMPS ① =S-T
T=0.
T=T+AMPS ①
AMPS ③ =AMPS ①
VOLTS ① =VOLTS ③ +OCV ③ -AMPS ③ *OHMS ③
T=0.
VOLTS ② =VOLTS ① -(T+AMPS ② )*OHMS ①
T=0.
AMPS ② =(VOLTS ② -VOLTS ③ )/OHMS ② -T
TRANSFER TO BACK
END OF PROGRAM
```

```
$ COMPILE MAD                                                    ITTR
          EXTERNAL FUNCTION (ARG1,ARG2,NC)
          ENTRY TO ITTR.
          WHENEVER .ABS.(ARG1-ARG2).G..01*(.ABS.ARG1),NC=1
          ARG1=(ARG1+ARG2)/2.
          END OF FUNCTION
          FUNCTION RETURN ARG1
```

7.6 NUMERICAL CALCULATIONS

The following is a numerical calculation of the Desired Results using the Complete Program. These calculations were carried out to show that the Complete Program does indeed yield the Desired Results to within a preselected accuracy limit. The accuracy limit, which was preselected in the iteration subroutine, is that the difference between the guessed and calculated values be less than 1% of the calculated value.

The values chosen for the Input Parameters are:

VOLTS (BATT(NEG)) = 0.
OCV (BATT(NEG)) = 10.
OHMS (BATT(NEG)) = 1.
OHMS (RES, 1(1)) = 10.
OHMS (RES, 2(1)) = 5.

Since the problem considered is simple, the closed expression for AMPS(RES, 2(1)) is given by the following expression:

$$\text{AMPS(RES, 2(1))} = \frac{\text{OCV(BATT(NEG))}}{\text{OHMS(BATT(NEG))} + \text{OHMS(RES, 1(1))} + \text{OHMS(RES, 2(1))}}$$

By making the appropriate substitution in the above equation, the actual value of AMPS(RES, 2(1)) is 0.625 amps. By comparing the actual value of AMPS(RES, 2(1)) to the value calculated by the Complete Program which was generated by the Performance Simulator, we see that the program did indeed give the Desired Results to the preselected accuracy limit.

NOTE: The following calculations have been simplified by deleting statements which are not pertinent in illustrating the calculation procedure but are pertinent to the actual machine calculations.

ALSO NOTE: REPEAT = 1B signifies the desired accuracy has not been obtained.
REPEAT = 0B signifies the desired accuracy has been obtained.
GAMPS represents Guessed Amps.

First Iteration	TRYCNT = 1
	REPEAT = 1B
Initial Guess	AMPS(2) = 0
	GAMPS(2) = 0
	AMPS(1) = 0
	AMPS(3) = 0
	VOLTS(1) = 10.
Calc	VOLTS(2) = 10.
Second Iteration	TRYCNT = 2
	REPEAT = 1B
Ittr	AMPS(2) = 1
	GAMPS(2) = 1
	AMPS(1) = 1
	AMPS(3) = 1
	VOLTS(1) = 9
	VOLTS(2) = -1
Calc	AMPS(2) = -.2
Third Iteration	TRYCNT = 3
	REPEAT = 1B
Ittr	AMPS(2) = .4
	GAMPS(2) = .4
	AMPS(1) = .4
	AMPS(3) = .4
	VOLTS(1) = 9.6
	VOLTS(2) = 5.6
Calc	AMPS(2) = 1.12
Fourth Iteration	TRYCNT = 4
	REPEAT = 1B
Ittr	AMPS(2) = .76
	GAMPS(2) = .76
	AMPS(1) = .76
	AMPS(3) = .76
	VOLTS(1) = 9.24
	VOLTS(2) = 1.64
Calc	AMPS(2) = .328

Fifth Iteration	TRYCNT = 5
	REPEAT = 1B
Ittr	AMPS(2) = .544
	GAMPS(2) = .544
	AMPS(1) = .544
	AMPS(3) = .544
	VOLTS(1) = 9.456
	VOLTS(2) = 4.016
Calc	AMPS(2) = .8032
Sixth Iteration	TRYCNT = 6
	REPEAT = 1B
Ittr	AMPS(2) = .6736
	GAMPS(2) = .6736
	AMPS(1) = .6736
	AMPS(3) = .6736
	VOLTS(1) = 9.3264
	VOLTS(2) = 2.5904
Calc	AMPS(2) = .51808
Seventh Iteration	TRYCNT = 7
	REPEAT = 1B
Ittr	AMPS(2) = .59584
	GAMPS(2) = .59584
	AMPS(1) = .59584
	AMPS(3) = .59584
	VOLTS(1) = 9.40416
	VOLTS(2) = 3.44576
Calc	AMPS(2) = .689152
Eighth Iteration	TRYCNT = 8
	REPEAT = 1B
Ittr	AMPS(2) = .642496
	GAMPS(2) = .642496
	AMPS(1) = .642496
	AMPS(3) = .642496
	VOLTS(1) = 9.357504
	VOLTS(2) = 2.932544
Calc	AMPS(2) = .5865088
Ninth Iteration	TRYCNT = 9
	REPEAT = 1B
Ittr	AMPS(2) = .6145024
	GAMPS(2) = .6145024
	AMPS(1) = 6145024
	AMPS(3) = .6145024
	VOLTS(1) = 9.3854976
	VOLTS(2) = 3.2404736
Calc	AMPS(2) = .64809472
Tenth Iteration	TRYCNT = 10
	REPEAT = 1B
Ittr	AMPS(2) = .63129856
	GAMPS(2) = .63129856
	AMPS(1) = .63129856
	AMPS(3) = .63129856
	VOLTS(1) = 9.3687014
	VOLTS(2) = 3.0557158

```
Calc                                AMPS(2)    = .61114316
Eleventh Iteration                  TRYCNT     = 11
                                    REPEAT     = 1B
Ittr                                AMPS(2)    = .62122086
                                    GAMPS(2)   = .62122086
                                    AMPS(1)    = .62122086
                                    AMPS(3)    = .62122086
                                    VOLTS(1)   = 9.3787791
                                    VOLTS(2)   = 3.1665704
Calc                                AMPS(2)    = .6331409
Twelveth Iteration                  TRYCNT     = 12
                                    REPEAT     = 1B
                                    AMPS(2)    = .62726748
                                    GAMPS(2)   = .62726748
                                    AMPS(1)    = .62726748
                                    AMPS(3)    = .62726748
                                    VOLTS(1)   = 9.3727325
                                    VOLTS(2)   = 3.1000577
Calc                                AMPS(2)    = .62001154
Thirteenth Iteration                TRYCNT     = 13
                                    REPEAT     = 1B
Ittr                                AMPS(2)    = .62363951
                                    GAMPS(2)   = .62363951
                                    AMPS(1)    = .62363951
                                    AMPS(3)    = .62363951
                                    VOLTS(1)   = 9.3763604
                                    VOLTS(2)   = 3.1399653
Calc                                AMPS(2)    = .62799307
Final Iteration                     TRYCNT     = 14
                                    REPEAT     = 0B
Ittr                                AMPS(2)    = .62581629
                                    GAMPS(2)   = .62581629
                                    AMPS(1)    = .62581629
                                    AMPS(3)    = .62581629
                                    VOLTS(1)   = 9.3741827
                                    VOLTS(2)   = 3.1160197
Final Calc                          AMPS(2)    = .62320395

                                    AMPS(RES,2(1))  = .62320395
```

NOTE: The program generated by the Performance Simulator went through one additional iteration after the preselected accuracy limit had been attained.

8 PERFORMANCE SIMULATOR STRUCTURAL DETAILS

After a language for communication of information concerning a system to be simulated is established, the job of the simulator program remains. That job is the translation of the various statements allowed by the language into an algorithm or solution procedure for the system simulation requested.

This is accomplished by several sections of program. The sections and their function are:

1) Preprocessing
2) Desired Result Reduction
3) Program Generation

The preprocessing phase consists of decomposing, analyzing, and regenerating the information from the source program statements in a form more easily handled by the machine. Input Parameters and Desired Results are saved in a very condensed form. Since each attachment point may have up to 70 parameters and these may fall into two groups (input parameters and desired results), each point must retain information on 140 items. Thus 200 attachments require 28000 items to be stored. These items are, fortunately, Boolean constants. In particular, the Boolean constant for an Input Parameter is 1 (True) if the parameter has been stated to be given. The constant is 0 (False) otherwise. For desired results, the constant is 1 if the parameter is required as an output and 0 otherwise. Since the computer is a binary machine it is possible to identify each of the 36 binary digits in the computer word with a specific parameter and thus save the status of 36 parameters in a single storage location. The entire parameter status is compressed into four words for each attachment by the Preprocessing section.

A second task of the Preprocessing section is to generate an image of the system to be simulated within the machine. This is done by forming a connection matrix. This array retains the nature of each attachment point. Each attachment is entered as the joint between two elements. Four items are required to specify uniquely an attachment on an element and thus eight locations specify a connection. The result is an 8 x n matrix, where n is the number of connections in the system. The matrix entries are the true names of the elements, attachments, and identifiers either as supplied directly by the connection statements or as replaced by synonyms.

The connection matrix thus generated may be quite disordered so far as efficient processing is concerned. After the matrix is completely entered in the machine a sorting is done using an indirect list address array to arrange the matrix in the order of occurrence of the Element Descriptions on magnetic tape. The indirect address lists allow the matrix to remain stationary in memory while the effective order is completely changed. Since the finding of information on magnetic tape is the most time consuming of all the operations every effort is used to save tape movement. The ordering also provides for an effective method for locating all occurrences of an element in the connecting array without searching the entire array. This is done as follows:

Let the connection array be denoted:

$$EL_{1L}\ EID_{1L}\ AT_{1L}\ AID_{1L}\ EI_{1R}\ EID_{1R}\ AT_{1R}\ AID_{1R}$$

$$EL_{2L}\ EID_{2L}\ AT_{2L}\ AID_{2L}\ EL_{2R}\ EID_{2R}\ AT_{2R}\ AID_{2R}$$

$$EL_{nL}\ EID_{nL}\ AT_{nL}\ AID_{nL}\ EL_{nR}\ EID_{nR}\ AT_{nR}\ AID_{nR}$$

Where

EL = any true element name

EID = any true element identifier

AT = any true element attachment name

AID = any true attachment identification

and the subscripts iL and iR denote the attachment point occurring to the "left" and to the "right" and the i-th such attachment point.

The ordering procedure is then:

1) Order the matrix by the EL_{iL} (and group each EL and EID) according to the arrangement of descriptions on the magnetic tape. Call this ordering vector "L".

2) Order the matrix by the EL_{iR} in the same way and call this ordering vector "R".

Let i be incremented from 1 through the number of connections, say n. Let Li (R_i) be the value of the i-th location in the L (R) vector. Then the i-th member of the EL_L (EL_R) is found in EL_{Li} (EL_{Ri}). This type of list addressing is known as "indirect" addressing.

3) Construct a vector for the vector L whose values are the locations of the first occurrence of each element addressed through L in the vector R. If no such occurrence exists in R, then insert the negative of the first occurrence of the element in L itself. Call this vector "L TO R".

4) Construct a similar vector for the vector R relating the occurrences in R to L. Call this vector "R TO L".

With these vectors the task is simplified for finding the entire set of occurrences of any identified element. The location of all occurrences is accomplished in the following way: (The method is given for L but is equally valid, with appropriate changes, for R)

1) If L TO R at a point is negative, the element does not occur in R. The first occurrence in L is found by taking the absolute value of L TO R.

2) Each entry in L agrees with the first as long as the corresponding L TO R corresponds to the first L TO R.

3) If L TO R is positive, the first L occurrence is found by going first to the first occurrence of the element in R and then back to L by using the associated R TO L value. The same test as in 2 applies to equivalent identified elements.

4) If L TO R is positive, the value gives the first R occurrence. The succeeding values in R are for the same identified element so long as R TO L for each succeeding value agrees with the first R TO L value.

The remaining task of Preprocessing is to save all input-output requirements and functions substitutions for the Program Generation. In addition, should the library complement be incomplete, the Preprocessing must construct the library entries. Each Element Description is saved as two files on the tape known as ELTAPE. The first saves the contents of each collection capability in 80 word blocks. This allows two words for input parameters and two words for desired results at each of the 20 allowable attachments. The words are in the

Boolean form previously described. Since two words allow for 72 parameters and only 70 parameters are allowed, the remaining bits are available for special use. In particular, the last bit in the desired result word is used to signal that this capability must apply to elements without this attachment.

The second file contains the MAD statements to generate the capability contained in the first file. The first capability group in the first file corresponds to the first collection of MAD statements in the second file and so on.

Upon completion of the Preprocessing, the status of the storage is as follows:

1) The connection matrix is in and contains only true names. The matrix is ordered and the input-output requirements have been packed in Boolean parameter words.

2) The Element Descriptions are processed and saved in groups of two files per description on tape ELTAPE, with all permanent description first.

3) The function substitutions and input-output parameters in complete notation are saved for the program generation phase on an erasable tape.

At this point, control is passed to the Desired Result Reduction section. This section is charged with the actual generation of the algorithm for simulating the system. The procedure for accomplishing this task is almost the reverse of the usual procedure used by humans in attempting the same task. The human approach, largely because of the extremely large storage capacity of the human brain, is a search that proceeds from the known parameters and is directed toward the desired results. This approach could be implemented in the machine but because of storage limitations may become quite unworkable. The difficulty is that the machine program cannot reject a method until it can be shown to be unnecessary in the program to obtain the desired results. Thus the program would be forced to enumerate all the possible methods available from the input parameters plus the results of the first set and so on. The number of methods available grows rapidly and if the problem is well-posed the desired results will eventually be encompassed. However, this constitutes an exhaustive search with only a small fraction of the methods actually of use.

Therefore a different approach is used. Essentially, the algorithm is produced in reverse by working from the desired results toward the input parameters. In this way every step generated is necessarily of use in the program. The program is, of course, backward, in that the first statement collection specified is the last one needed and so on but this is easily taken care of by the Program Generation section. The method of production of the algorithm is the following:

Step 1. Inspect the "Desired Result" Boolean words for each connection point in the matrix. Whenever no Desired Result bits can be found in the entire matrix the algorithm is completed.

Step 2. Whenever a connection is found for which results are desired, steps must be taken to satisfy the request for results.

2A. The requested results may be input parameters. If this is so, remove the corresponding desired result bits.

2B. The requested results may occur at any identified attachment and be of broad scope. If this is so and the result (as an input parameter) can be found at any of the identified attachments, remove the corresponding desired result bit.

2C. If requested results still remain after Steps 2A and 2B, then some additional program must be added to obtain the results.

2C1. Find all of the statement collections for both elements that occur at this attachment point that are useful in obtaining the requested results. That is, ignore any collections that are "without" attachments specified for this element or collections that do not happen to produce any of the desired results.

2C2. Check each useful collection to determine its effectiveness. The effectiveness is the ratio of the number of requested results the collection produces to the number of new requests for results the collection will produce. A new request for results will occur if any of the parameters required by the collection is not an input parameter or already requested by previous statements.

If the number of new requests for results is zero, the collection is always inserted in the algorithm. This collection produces results without requiring any new information.

(The only exception to this rule occurs with the iterative ESTIMATE collection. In this case, no new information request is apparent, however, the ESTIMATE collection is restrained from inclusion in the program until the parameter in question is found by at least one independent calculation method.) Otherwise, retain the effectiveness ratio as the weight of the collection.

2C3. When all of the collections have been examined for effectiveness and if desired results still remain, select a set of the collections that will produce the requested results.

At this point, the methods in which a parameter could be found using a method only once at a given attachment point are checked and discarded if already used. Otherwise, these methods are simply placed in competition with any other techniques available.

2C3A. First check to be certain that every requested result can be found in at least one way. If any result cannot be so found, the problem may not be well posed. The problem is not well posed if no "branches" have occurred previously in the generation. A "branch" occurs when a choice is made between more than one method of determining a requested result.

2C3B. Whenever there is exactly one method for producing a result, this method must be included at this point in the algorithm. The method is inserted, the results produced by the method have the corresponding bits removed, and any new requests occurring anywhere in the matrix have the corresponding bits inserted.

2C3C. After all single method results are taken care of there remain only results for which there are several used for each result the selection will constitude a "branch" in the algorithm generation, if the method selected is not always forced to be the same one.

If one considers the available methods, each with its associated weight, the simulator should tend to choose the method of greatest weight. However, the simulator should be allowed to select the method on the basis of the probability of selection being proportional to the weight. If this is not done, one may anticipate that in some case the method of greatest weight may contain a parameter that is incapable of calculation (consider-

ing the input parameter) and therefore the program could not by generated. If, however, the simulator makes the selection probabilistically, the method of greatest weight is most likely to be selected although other methods may be selected in its place. The probabilistic selection is automatically made and the "branch" Boolean constant is set to one. In this way, if later there should arise a case in which no method is available, the simulator may make another trial and possibly work out a satisfactory algorithm by having the chance to choose another method at this point. This is a situation in which the locally "best" method is not always the globally "best" but tends to be so.

Step 3. Steps 1 and 2 are repeated over and over. Each time the requested results are satisfied, a new set of requests are generated except when the request matches an input parameter. If the problem is well posed then a sequence of methods may be found such that all desired results are satisfied, through the sequence, by input parameters. When this has been done, an algorithm for the simulation of the system has been produced.

The algorithm produced tends to be optimal since at each state the method of greatest weight was most likely to be employed but the simulator cannot, with limited storage, view the generation of the algorithm beyond a single step. Thus occasionally the simulator may produce several steps that might be condensed if more information were available. In particular, it may happen that identical set of statements may be produced in the algorithm at different stages of the generation. This redundancy is easily detected and the final algorithm will contain only the first occurrence of the set.

The method of probabilistic selection is also used to discard the least likely method should there be found too many methods to apply at a given point.

The method of probabilistic selection for picking an item from a group on n weighted items is the following.

Let $W > 0$ be the weight of the i-th item from a group of n total items.

Let $W = \sum_{i=1}^{n} W_i$ be the total weight of the group.

Let N_0^W be a random number selected from a uniformly distributed set of random numbers on the interval 0, W.

Then the K-th member of the group if n items will be selected for the smallest K such that

$$\sum_{i=1}^{K} W_i \geq N_0^W .$$

N_0^W is most likely to fall in the subinterval such that W_i is maximum but may fall anywhere in the interval. A modification of this method to pick the least likely item (for discard, etc.) consists of defining a new set of weight $\rho = 1/W_i$ and making the selection using ρ in place of W. It should be noted particularly that equally probable alternatives receive equal chances and every alternative, no matter how small its weight may be, receives some consideration and may be chosen at any time. This method should find many applications in future programs.

Since there is no way to predict either the number of parameters that may be needed at a point or the number of methods available for any parameter it is necessary to allow an extremely flexible storage assignment so that the storage may be completely used. This is done by means of an "associative memory" list for the storage region. This list functions as follows:

1) Associated with each parameter at the attachment point is a storage location whose value is:

   1A) Zero if the parameter is not required.

   1B) Minus one if the parameter is not required and no method has yet been found to yield the parameter.

   1C) Otherwise, the value is a positive integer giving the location of the beginning of the list of methods for this parameter in the "associative memory".

2) Each entry in the associative memory list gives the location of the next (associated) entry. The final entry is denoted by a minus sign.

3) New entries are made by consulting the associative memory list beginning at the 0th location. The value of this location is the next available location in the memory. An addition to the end of any list is made in the available location, the value that was in this location is stored in the 0 th location and the former list end is changed to refer to the new list end.

4) Whenever a result collection is selected, the storage space is reassigned as available storage by placing the starting location for the list in the 0th location, and the value formerly in the 0th location at the end of the list being removed. In this way the entire list is made available with only two storage reassignments.

5) If the capacity of the storage is exceeded before all the parameters have been treated space can be created by selecting the parameter with the greatest number of methods and picking the method least likely using the probabilistic section technique. The location thus chosen is made available by giving its address to the 0th location and reassigning the preceeding list location to skip this location and refer to the next item in the list.

Upon completion of the removal of all the desired results and those created during the removal of others, the algorithm is completed and written in reverse order on magnetic tape. This type of storage is used because it is not possible to predict the storage required for a program in advance. This is somewhat unfortunate since the program is generated in the form of a "push down" list. A push down list is a list such that each entry occurs at the beginning (rather than the end) of the list and thus moves the former first item to second place, the former second to third and so on. Thus the items are "pushed down" on the list. Removal of items from the list occurs from the beginning of the list with the last item entered. Thus the effective order of the list is reversed. This is precisely the action that must occur in the program generated since the last statement collection found must be the first used in the program and the first collection found is the last one used in the program. The difficulty is resolved by moving the tape backward two records and forward one working from the last record written toward the first.

As this process is begun after the completion of the algorithm, the simulator is at this point generating the simulation program using the Program Generator. The first output of the Program Generator is the Prologue and its associated input-output statements. The Prologue is followed by the program. The algorithm is stored in a short code giving the connection matrix row number and index in the L vector so that the unique connection could be located by the program generator, the element description name given by position in the element name vector and tagged with a plus (+) sign if the element involved was the left-most and a minus (-) sign if the right-most, and finally the statement collection number. The program generator section moves to the second file in the desired element description and next to the appropriate statement collection. Finally the statement collection is processed and produced both on cards and in print to form the desired simulation program. The rules by which the processing takes place have been stated in the section describing Element Descriptions. Briefly, the MAD statements are written using floating statement labels, and special codes for function substitutions and for parameter and attachment codes. The Program Generator assigns unique fixed statement labels for the floating statement labels. Any function substitution is checked for possible modification. If a substitution has been requested, the substitution is made, otherwise the original text is retained. The parameter and attachment codes are reduced to a six character variable name code for each parameter-attachment combination occurring. Some of the six characters may be blanks. Non-identified attachment parameters are immediately coded and inserted in the output statement. Identified attachments cause multiple copies of the statement to be generated. One copy is made for each different identifier. To avoid possible ambiguity, only one attachment may be identified in each statement. However, this attachment may occur any number of times with any number of parameters within one statement. In this way the effect of a special junction element is produced without specifically requiring such an element.

As noted in the Collection Capability section, there is one exception to this rule. Namely, when an attachment is identified and the current point in the connection matrix agrees exactly with this attachment name, a copy of the statement is produced for all occurrences except the current one. Finally, if an attachment is not identified, the current attachment point will be selected if the name agrees with the name occurring in the collection statement. Otherwise, the first occurrence of the name is used in the code.

Upon completion of the program generation the control is returned to the Preprocessing Section to process any other system simulation problems that may be waiting. Since the output of this program is a program in MAD code and on punched cards, the simulation program may be used as it is produced or modified easily before using it to simulate the system. To use the program as it is generated, the user need only supply the data and special subroutines needed and the special cards needed by the executive system for the data processing system. The program will be translated into machine code and executed using the data supplied.

```
$COMPILE MAD,EXECUTE,DUMP,PUNCH OBJECT,PRINT OBJECT                    CORE100
         R'N
STCC(0)  CONTINUE
         EXECUTE PLACE.(FPAR(0),69,0)
         EXECUTE PLACE.(ZPAR(0),69,0)
STCC(1)  CONTINUE
         EXECUTE PLACE.(A(0),15599,$ $)
         A(15853)=2
         A(15854)=401
         A(15855)=400
         ABRSW=0B
         ATTCNT = 0
         CAT = 0B                                                      0320
         CCNT = 0                                                      0340
         CEID = 0B                                                     0310
         CEL = 0B                                                      0300
         CKRN=0B
         CLC=0B                                                        0720
         CSIDE = 0                                                     0330
         CSUB = 0                                                      0350
         CTO = 0B                                                      0290
         DCNT = 0
         DONE = 0B
         E2NDPN = 0B                                                   0500
         EAT = 0B                                                      0480
         ECNT = 0                                                      0510
         EEID = 0B                                                     0470
         EEL =0B                                                       0460
         EOFB = 0B
         EPAR = 0B                                                     0450
         ESUB = 0                                                      0520
         FIVE = 9
         FOUR=4
         FSCNT = 0                                                     0680
         FSEL = 0B                                                     0670
         FSNEW = 0B                                                    0650
         FSOLD = 0B                                                    0660
         FSSUB = 0                                                     0690
         I= 71
         ID1=$ $                                                         40
         ID2=$ $                                                         50
         IFERR1=0B                                                     0560
         IFERR2=0B                                                     0570
         K1=0                                                          0550
         LASTCH=$.$                                                      60
         NTAPE=0B                                                      0710
         NUELTP = 0B                                                    721
         OUT=0B                                                        0640
         PARCNT = 0
         PAT=0B                                                        0610
         PCNT=0                                                        0620
         PCNT(1)=0                                                     0630
         PEID=0B
         PEL=0B                                                        0600
         PELCNT = 0
         PEQL=0B
         PLP1=0B                                                       0580
         PLP2=0B                                                       0590
         PNUM = 0
```

```
          PNUM(1) = 0
          PPER=0B
          S1STEQ = 0B                                                    0410
          S1STPN = 0B
          S2NDPN = 0B                                                    0400
          SAT = 0B                                                       0390
          SBIT(0) = 0
          SBIT(1) = 0
          SCNT = 0                                                       0420
          SCOPB1 = 0
          SCOPB2 = 0
          SEID = 0B                                                      0380
          SEL = 0B                                                       0370
          SPAR = 0B                                                      0360
          SSIDE = 0                                                      0440
          SSUB = 0                                                       0430
          TC = THREE
          TELCNT = 0
          THREE=3
          TIME = 60
          EXECUTE TODAY.(Z1,Z2)
          Z3=DAYTIM.(0)
          ZH=Z3/216000
          ZM=(Z3-ZH*216000)/3600
          ZS=(Z3-ZH*216000-ZM*3600)/60
          W'R ZH .L. 12
          Z4=$AM$
          O'R ZH .E. 12
          Z4=$PM$
          O'E
          Z4=$PM$
          ZH=ZH-12
          E'L
          P'T $H*1DATA AS GIVEN TO SYSTEM SIMULATOR*,S60,2C6,S5,I2,I3,
         1I3,S1,C6*$,Z1,Z2,ZH,ZM,ZS,Z4
          READ AND PRINT DATA  (IDENT,TIME)  (TIME IS OPTIONAL)
          EXECUTE START.(IDENT)
          EXECUTE SETEOF.(EOF1)
          TRANSFER TO RESET1                                             0750
READ1     EXECUTE INPUT.(CH...END1,WORD)
          EQUIVALENCE(EOF1,END1)
          WHENEVER NTAPE.OR.CLC                                          0770
WTAPE     CONTINUE
          WRITE BINARY TAPE TC, WORD(0),...., WORD(11)
          WHENEVER  CH.NE.$+$, TRANSFER TO READ1                         0800
          WHENEVER CLC                                                   0810
          CLC=0B                                                         0820
          PRINT COMMENT $0CALCS$
          END OF FILE TAPE THREE
          CLDONE = 1B
         R                    CALCULATIONS ARE NOW ON TAPE THREE
          TRANSFER TO CLBCK                                              0830
          END OF CONDITIONAL                                             0840
          PRINT COMMENT $0(EOF4)$
          END OF FILE TAPE FOUR
         R                    PROLOGUE IS NOW ON TAPE FOUR
          NTAPE = 0B                                                     0860
CLBCK     I = 71
          DCNT=0                                                         0870
```

```
          LASTCH=$.$
          TRANSFER TO RESET1                                              0900
          END OF CONDITIONAL                                              0910
          WHENEVER CH.E. $/$, TRANSFER TO READ1                           0920
          WHENEVER  CH .E. $*$                                            0930
          ID1=WORD(1)                                                     0940
          ID2=WORD(2)                                                     0950
          TRANSFER TO READ1                                               0960
          END OF CONDITIONAL                                              0970
          WHENEVER LASTCH .NE. $.$ .AND. CH .NE. -$=$                     0980
          LASTCH=$.$                                                      0990
          I=-1
          TRANSFER TO S(K1,1)                                             1020
          END OF CONDITIONAL                                              1030
          THROUGH LOOP, FOR I = 0 , 1, I .G. 71                           1040
          NUCHAR = CH(I)                                                  1050
          WHENEVER NUCHAR.E.$ $, TRANSFER TO LOOP                         1060
          LASTCH=NUCHAR                                                   1070
ERRTST    THROUGH ERRTST, FOR K=0,1,NUCHAR.E.ILCHAR (K).OR.K.G.5          1080
          VECTOR VALUES ILCHAR=$+$,$-$,$/$,$*$,$0$,$0$                   1090
          WHENEVER K.LE.5                                                 1100
          P'T ERR1,I+1
          V'S ERR1=$H*0ILLEGAL CHARACTER IN THE ABOVE LINE, CC *I2,/*$
          IFERR1=1B                                                       1150
          I = 71
RESET1    HOLCNT=1                                                        1180
          NUWORD=$ $                                                      1190
          TRANSFER TO LOOP                                                1200
          END OF CONDITIONAL                                              1210
         R
         R                                        PUNCTUATION CHECK
PUNTST    THROUGH PUNTST, FOR K=0, 1, NUCHAR.E.PUNCT (K). OR. K.G.4       1220
          VECTOR VALUES PUNCT=$,$,$.$,$($,$)$,$=$                         1230
          W'R K .LE. 4 .OR. HOLCNT .G. 6 .OR. ABRSW
                TRANSFER TO S(K1,K)
          END OF CONDITIONAL
          NUWORD=INSRTC.(NUWORD,HOLCNT,NUCHAR)                            1250
          HOLCNT=HOLCNT+1                                                 1260
          W'R NUCHAR .E. $'$, ABRSW=1B
LOOP      CONTINUE                                                        1270
         R                                        READ IN NEXT CARD
          TRANSFER TO READ1                                               1280
         R                                        END OF FILE ON INPUT
         R      (**PROGRAM FINISHED. NO MORE DATA**)
EOF1      EOFB=1B                                                         1300
          EXECUTE END.(0)
         R    (** NEXT SET OF DATA IS READY, COMPLETE THIS PROGRAM FIRST
         R                                        NEXT SET OF DATA
NXTSET    CUT=1B                                                          1360
          EXECUTE END.(1)
         R                                        FINISH PROCESSING
          REWIND TAPE FOUR
          WRITE BINARY TAPE THREE,$FSUB.$,FSCNT,FOMAT...FOMAT(5)
          V'S FOMAT=$PADPADPADPADPADPADPADPADPADPADPAD$
          T'H TLOOP, FOR I=0,1, I .E. FSCNT
TLOOP     WRITE BINARY TAPE THREE,A(0,I),A(1,I),A(2,I),A(3,I)
          END OF FILE TAPE THREE
          WRITE BINARY TAPE THREE,$INPUTT$,PCNT(0),FOMAT...FOMAT(5)
          T'H ILOOP, FOR I=0,1, I .E. PCNT(0)
```

```
ILOOP       WRITE BINARY TAPE THREE,A(4,I),A(5,I),A(6,I),A(7,I),A(8,I)
            END OF FILE TAPE THREE
            WRITE BINARY TAPE THREE,$DESRUS$,PCNT(1),FOMAT...FOMAT(5)
            T'H DLOOP, FOR I=0,1, I .E. PCNT(1)
DLOOP       WRITE BINARY TAPE THREE,A(9,I),A(10,I),A(11,I),A(12,I),A(13,I
           1)
            END OF FILE TAPE THREE
            REWIND TAPE THREE
            W'R NUELTP
           R                    FILE 1 MUST BE REWRITTEN FOR NEW TAPES.
            WRITE BINARY TAPE FOUR,$ELTAPE$,IDENT,FOMAT...FOMAT(5)
            WRITE BINARY TAPE FOUR,PELCNT,TELCNT,PARCNT,FOMAT...FOMAT(5)
            WRITE BINARY TAPE FOUR,A(15604)...A(15853)
            REWIND TAPE FOUR
            E'L
           R    (** PROCESS DATA IN A MATRIX WITH SIMULATOR SUBROUTINES.*$.
            EXECUTE END.(2)
           R   DECLARATION SECTION K1=0**********************************      1470
S(35)       CONTINUE                                                          1480
S(29)       CONTINUE                                                          1490
S(23)       CONTINUE                                                          1500
S(17)       CONTINUE                                                          1510
S(11)       CONTINUE                                                          1520
            K1=0                                                              1530
S(5)        W'R ABRSW
ABRINS      ABRSW=0B
            NUWORD=INSRTC.(NUWORD,HOLCNT,NUCHAR)
            E'L
            DWORD(DCNT)=NUWORD
           R
            DCNT=DCNT+1                                                       1550
            WHENEVER DCNT.G.4, TRANSFER TO S(4)                               1560
            TRANSFER TO RESET1                                                1570
S1(17)      T'H S1(17), FOR N=0,1, ABR1(N) .E. DWORD .OR. N .G. MAXCNT
            W'R N .G. MAXCNT, T'O S(4)
            T'O S1(N)
S(0)        CONTINUE                                                          1580
S(2)        CONTINUE                                                          1590
S(3)        CONTINUE                                                          1600
S1(18)        CONTINUE
S1(19)        CONTINUE
S1(20)        CONTINUE
S(4)        PRINT COMMENT $0***** DECLARATION ERROR IN THE LINE ABOVE$
            P'T DWORDA,DWORD...DWORD(DCNT-1)
            V'S DWORDA=$1H0,22C6*$
            IFERR2=1B                                                         1630
INS(1)      DCNT=0                                                            1640
            I = 71
            TRANSFER TO RESET1                                                1670
S(1)        DWORD(DCNT)=NUWORD                                                1680
            DCNT=0                                                            1690
DCL         THROUGH DCL, FOR N=0, 1, DKIND1(N).E.DWORD (0).AND.DKIND2(N)      1700
           1.E. DWORD(1).OR.N.G. MAXCNT
            VECTOR VALUES MAXCNT= 16
            TRANSFER TO S1(N)                                                 1720
           R             ELEMENT DESCRIPTION SECTION K1 = 6
S1(0)       K1 = 6
              WHENEVER .NOT. ELTPOK.AND.PELCNT.G.0.AND..NOT.NUELTP,
           1EXECUTE SKFILE.(FOUR,2*(PELCNT-1))
```

```
            NOATS=0
            ELTPOK=1B
            TRANSFER TO RESET1
           R
           R                    INPUT PARAMETERS
S1(1)       K1=3                                                        1740
            K2 = 4
            K3=0                                                        1760
            PNUM(K3)=0
            TRANSFER TO RESET1                                          1770
           R                    SYNONYM (S)
S1(12)      CONTINUE                                                    1780
S1(2)       K1=2                                                        1790
            TRANSFER TO RESET1                                          1800
           R                    CONNECTION (S)
S1(11)      CONTINUE                                                    1810
S1(3)       K1=1                                                        1820
            TRANSFER TO RESET1                                          1830
           R                    DESIRED RESULTS
S1(4)       K1=3                                                        1840
            K2 = 9
            K3=1                                                        1860
            PNUM(K3)=0
            TRANSFER TO RESET1                                          1870
           R                    FUNCTION SUBSTITUTIONS
S1(16)        CONTINUE
S1(5)       K1 = 4                                                      1880
            TRANSFER TO RESET1                                          1890
           R                    NEW ELEMENT TAPE.
S1(6)       CONTINUE
            NTAPE=1B                                                    1940
           R                   (SYSTEM INPUT ON TAPE TWO.)
            NUELTP = 1B
            TC = FOUR
            WHENEVER I.LE. 0, TRANSFER TO WTAPE
            TRANSFER TO READ1                                           1960
           R                    CALCULATION (S)
S1(13)      CONTINUE                                                    1970
S1(7)       CLC=1B                                                      1980
            CLDONE = 0B
            TC = THREE
            END OF FILE TAPE THREE
            WRITE BINARY TAPE THREE, $  CALC  CALC  CALC  CALC  CALC  $
            WHENEVER I.LE. 0, TRANSFER TO WTAPE
            TRANSFER TO READ1                                           2000
           R                    NEXT SET OF DATA
S1(8)       TRANSFER TO NXTSET                                          2010
           R                    CHECK RUN
S1(10)      CONTINUE                                                    2020
S1(9)       CKRN=1B                                                     2030
            TRANSFER TO RESET1                                          2040
           R                    EQUIVALENCE
S1(15)      K1 = 5                                                      2050
           R                    SAVE TAPE
S1(14)      TRANSFER TO RESET1                                          2060
           R  OTHER TYPES OF ERRORS ***************************************  2160
           R                                 =   IN CONNECTIONS STATE.
S(10)       CONTINUE                                                    2200
           R                                = IN FUNCTION SUBSTITUTION
```

```
S(28)       CONTINUE
            PRINT COMMENT $OILLEGAL EQUAL SIGN ABOVE****$
            IFERR1=1B                                                    2270
            TRANSFER TO RESET1                                           2280
           RSYNONYM SECTION K1=2       ************************************ 2830
           R   SYNONYM STATEMENT DECOMPOSTION                            2840
           R                                  COMMA IN SYNONYMS
S(12)       WHENEVER .NOT. SEL .AND. .NOT. S2NDPN                        2850
            SSUB = 22                                                    2860
            SEL = 1B                                                     2870
            OR WHENEVER .NOT. SAT .AND. S2NDPN                           2880
            SSUB = 24                                                    2890
              SAT = 1B                                                   2900
              WHENEVER NUWORD .E. $0$, NUWORD = $ $                      2910
            OR WHENEVER  .NOT. SEID .AND. .NOT. S2NDPN                   2920
            SSUB = 23                                                    2930
              SEID = 1B                                                  2940
            END OF CONDITIONAL                                           2950
            TRANSFER TO SENTER                                           2960
           R                                PERIOD IN SYNONYMS
S(13)       SSIDE = 0                                                    2970
            S1STEQ  = 0B                                                 2980
SPRIOD      WHENEVER .NOT. SPAR, A(26,SCNT) = NUWORD                     2990
            SCNT = SCNT+1                                                3000
            WHENEVER SCNT .G. 398                                        3010
            SCNT = SCNT -1                                               3020
            PRINT COMMENT $0SYNONYM TABLE LENGTH EXCEEDED$
            END OF CONDITIONAL                                           3050
SRESET      SPAR = 0B                                                    3060
            SEID = 0B                                                    3070
            SAT = 0B                                                     3080
            SEL = 0B                                                     3090
            S1STPN= 0B
            S2NDPN = 0B
            BOOLEAN S1STPN
            TRANSFER TO RESET1                                           3100
           R                                LEFT PAREN IN SYNONYMS
S(14)       CONTINUE
            WHENEVER S1STPN, S2NDPN= 1B
            S1STPN= 1B
            WHENEVER NUWORD.E. $ $
                  WHENEVER .NOT. SPAR, SPAR= 1B
                  TRANSFER TO RESET1
                  END OF CONDITIONAL
            WHENEVER  .NOT. SPAR                                         3130
            SSUB = 21                                                    3140
            SPAR = 1B                                                    3150
            S2ND PN = 0B                                                 3160
            OR WHENEVER .NOT. SEL                                        3170
            SSUB = 22                                                    3180
            SEL = 1B                                                     3190
            OR WHENEVER .NOT. SEID                                       3200
            SSUB = 23                                                    3210
            SEID = 1B                                                    3220
            END OF CONDITIONAL                                           3230
            TRANSFER TO SENTER                                           3240
SENTER      A(SSUB+SSIDE,SCNT) = NUWORD                                  3250
            TRANSFER TO RESET1                                           3260
           R                                RIGHT PAREN IN SYNONYMS
```

```
S(15)      WHENEVER NUWORD .E. $ $, TRANSFER TO RESET1                    3270
             WHENEVER .NOT. SEL                                           3280
              WHENEVER  .NOT. S2NDPN                                      3290
                SEL = 1B
                SSUB= 22
           CR WHENEVER .NOT. SAT                                          3310
                SSUB = 24
                SAT = 1B
           OTHERWISE                                                      3330
                SSUB = 25
           END OF CONDITIONAL                                             3350
           OR WHENEVER .NOT. SEID .AND..NOT. S2NDPN                       3360
                SSUB = 23
                SEID = 1B
           OR WHENEVER .NOT. SAT                                          3380
                SAT = 1B
                SSUB = 24
           OTHERWISE                                                      3400
           SSUB = 25                                                      3410
           END OF CONDITIONAL                                             3420
           TRANSFER TO SENTER                                             3430
          R                                  EQUAL SIGN IN SYNONYMS
S(16)      WHENEVER S1STEQ                                                3440
           THROUGH SREWRT, FOR SSUB= 21,1, SSUB .G. 25                    3450
SREWRT     A(SSUB,SCNT+1) = A(SSUB,SCNT)                                  3460
           TRANSFER TO SPRIOD                                             3470
           OTHERWISE                                                      3480
           WHENEVER .NOT. SPAR, A(21, SCNT) = NUWORD                      3490
           SSIDE = 5                                                      3500
           S1STEQ = 1B                                                    3510
           TRANSFER TO SRESET                                             3520
           ENDOF CONDITIONAL                                              3530
          R INPUT PARAMETERS  K1=3 K2=4  K3=0**************************   3540
          R  DESIRED RESULTS  K1 = 3 K2=9  K3 = 1                         3550
          RCOMBINED LOADER                                                3560
          R  MAXIMUM OF 400 INPUT PARAMETERS                              3570
          R  MAXIMUM OF 400 DESIRED RESULTS                               3580
          R                                  COMMA IN IPOR DR
S(18)       CONTINUE
           PEQCNT=PEQCNT+1
           WHENEVER NUWORD.E.$ $,TRANSFER TO RESET1
           W'R PEQL
               A(14,ECNT)=NUWORD
               T'H PEQU, FOR PJ=0,1, PJ .G. 4
PEQU           A(15+PJ,ECNT)=A(K2+PJ,PCNT(K3)+PEQCNT)
               T'O ECNTIC
           E'L
           WHENEVER PLP1
             WHENEVER .NOT. PEL
               PEL= 1B
               CJ=1
             OR WHENEVER .NOT. PAT
                 PAT= 1B
           CJ=3
           OR WHENEVER .NOT. PEID
           PEID = 1B
           CJ=2
             OTHERWISE
           CJ=4
```

```
          END OF CONDITIONAL
         A(K2+CJ,PCNT(K3))= NUWORD
         TRANSFER TO RESET1
         END OF CONDITIONAL
         TRANSFER TO PNCNT                                                    3670
        R                                  PERIOD IN IP OR DR
S(19)    PPER=1B
         W'R PEQL, T'O S(18)
PERET    T'H PCOPY, FOR PI=1,1, PI .GE. PNUM(K3)
         THROUGH PCOPY,FOR PJ=1,1,PJ.G.4                                      3690
PCOPY    A(K2+PJ,PCNT(K3)+PI)=A(K2+PJ,PCNT(K3))                               3700
         PCNT(K3)=PCNT(K3)+PNUM(K3)                                           3710
         WHENEVER PCNT(K3) .G. 379                                            3720
POVR     PRINT COMMENT $ODRIPOR$
         END OF CONDITIONAL                                                   3740
         PAT=0B                                                               3780
         PEID= 0B
         PEL=0B                                                               3770
         PEQL=0B
         PLP1=0B                                                              3750
         PLP2=0B                                                              3760
         PNUM(K3)=0                                                           3790
         PPER=0B
         TRANSFER TO RESET1                                                   3800
        R                                  LEFT PAREN IN IP OD DR
S(20)    CONTINUE
         WHENEVER PLP1
         PLP2=1B                                                              3820
         CJ=1                                                                 3830
         WHENEVER PEL
           CJ=2
         PEID= 1B
         END OF CONDITIONAL
         PEL =1B                                                              3850
         WHENEVER NUWORD .E. $ $, TRANSFER TO RESET1
         TRANSFER TO OMTD                                                     3860
         OTHERWISE                                                            3870
         PLP1=1B                                                              3880
         WHENEVER NUWORD.E. $ $, TRANSFER TO RESET1
PNCNT    A(K2, PCNT(K3)+PNUM(K3))= NUWORD                                     3890
         PNUM (K3)=PNUM(K3)+1                                                 3900
         WHENEVER PCNT(K3)+PNUM(K3).G.399,TRANSFER TO POVR                    3910
         END OF CONDITIONAL                                                   3920
         TRANSFER TO RESET1                                                   3930
        R                                  RIGHT PAREN IN IP OR DR
S(21)    CONTINUE
         WHENEVER PLP2 .AND. PLP1
         CJ=3                                                                 3950
         WHENEVER PAT, CJ=4                                                   3960
         PLP1=0B                                                              3970
         OR WHENEVER PLP1                                                     3980
         CJ=1                                                                 3990
         WHENEVER PEL, CJ=2                                                   4000
         OTHERWISE                                                            4010
         TRANSFER TO RESET 1                                                  4020
         END OF CONDITIONAL                                                   4030
OMTD     A(K2+CJ, PCNT (K3))= NUWORD                                          4040
         TRANSFER TO RESET1                                                   4050
        R                                EQUAL SIGN IN IP OR DR.
```

```
S(22)       PEQL=1B
            PEQCNT=-1
            T'H PEQINT, FOR PI=1,1, PI .GE. PNUM(K3)
            T'H PEQINT, FOR PJ=1,1, PJ .G. 4
PEQINT      A(K2+PJ,PCNT(K3)+PI)=A(K2+PJ,PCNT(K3))
            T'O RESET1
           R
           R   FUNCTION SUBSTITUTIONS  ************************************    4060
           R                                  COMMA IN FUNCTION SUBSTIT.
S(24)       WHENEVER .NOT. FSNEW                                              4070
            FSSUB = 0                                                         4080
            FSNEW = 1B                                                        4090
            OR WHENEVER .NOT. FSOLD                                           4100
           R                                  LEFT PAREN IN FSB
            TRANSFER TO S26P
S(26)       CONTINUE
S26P        W'R NUWORD .E. $ $, T'O RESET1
            FSSUB = 1                                                         4120
            FSOLD = 1B                                                        4130
            OTHERWISE                                                         4140
                 FSEL = 1B
            FSSUB = 2                                                         4150
            END OF CONDITIONAL                                                4160
            TRANSFER TO FENTER                                                4170
           R                                  RIGHT PAREN IN FSB
S(27)       WHENEVER .NOT. FSEL                                               4180
                 FSEL = 1B
            FSSUB= 2                                                          4190
            OTHERWISE                                                         4200
            FSSUB = 3                                                         4210
            END OF CONDITIONAL                                                4220
            TRANSFER TO FENTER                                                4230
           R                                  PERIOD IN FSB
S(25)       WHENEVER .NOT. FSOLD,A(1,FSCNT)= NUWORD                           4240
            FSNEW = 0B                                                        4250
            FSOLD = 0B                                                        4260
            FSEL = 0B                                                         4270
            FSSUB=0
            FSCNT = FSCNT +1                                                  4280
            WHENEVER FSCNT .G. 399                                            4290
            FSCNT = FSCNT -1                                                  4300
            PRINT COMMENT $0FUNCTION SUBSTITUTION TABLE LENGTH EXCEEDED$
            END OFCONDITIONAL                                                 4340
            TRANSFER TO RESET1                                                4350
FENTER      A(FSSUB,FSCNT )= NUWORD                                           4360
            TRANSFER TO RESET1                                                4370
           RCONNECTION SECTION K1=1 ************************************     2290
           R  CONNECTIONS IN A(30,0)...A(38,399)                              1460
           RMAX OF 400 CONNECTIONS                                            2300
           R                                  COMMA IN CONNECTIONS
S(6)        WHENEVER NUWORD.E.$TO$                                            2310
              CTO = 1B                                                        2320
                WHENEVER CSIDE.E. 0
             CSIDE = 4                                                        2340
             OTHERWISE                                                        2350
              THROUGH RECOPY, FOR CSUB=31,1,CSUB.G. 34                        2360
RECOPY        A(CSUB,CCNT+1) = A(CSUB+4,CCNT)                                 2370
            WHENEVER A(37,CCNT).E. $ $,A(37,CCNT) = $1$                       2380
            WHENEVER A(33,CCNT+1) .E.$ $,A(33,CCNT+1)=$2$                     2390
```

```
CRESET      CCNT = CCNT+1                                                    2400
            WHENEVER CCNT .G. 399                                            2410
            CCNT =CCNT-1                                                     2420
            PRINT COMMENT $OCONOVR$
            END OF CONDITIONAL                                               2440
            END OF CONDITIONAL                                               2450
            CEL = 0B                                                         2460
            CEID = 0B                                                        2470
            CAT = 0B                                                         2480
            TRANSFER TO RESET1                                               2490
            OR WHENEVER NUWORD .E. $ $                                       2500
            TRANSFER TO RESET1                                               2510
            OR WHENEVER .NOT. CEL                                            2520
              CSUB = 31                                                      2530
            CEL = 1B                                                         2540
            CR WHENEVER .NOT. CEID                                           2550
            CSUB = 32                                                        2560
            CEID = 1B                                                        2570
            OTHERWISE                                                        2580
                  CAT= 1B
                  CSUB= 33
            END OF CONDITIONAL                                               2600
            TRANSFER TO CENTER                                               2610
           R                                  PERIOD IN CONNECTIONS
S(7)        CONTINUE
            WHENEVER CTO
                  WHENEVER .NOT. CEL
                        A(35,CCNT)= NUWORD
                  OR WHENEVER .NOT. CEID
                        A(36,CCNT)= NUWORD
                  END OF CONDITIONAL
                  CSIDE = 0
                   CSUB = 31
               END OF CONDITIONAL
            TRANSFER TO CRESET                                               2670
           R                                  LEFT PAREN IN CONNECTIONS
S(8)        WHENEVER NUWORD .E. $ $,TRANSFER TO RESET1                       2680
            WHENEVER .NOT. CEL                                               2690
            CSUB = 31                                                        2700
            CEL = 1B                                                         2710
            CEID = 1B
            OTHERWISE
                  CSUB= 32
                  CEID = 1B
            END OF CONDITIONAL                                               2720
            TRANSFER TO CENTER                                               2730
           R                                  RIGHT PAREN IN CONNECTIONS
S(9)        WHENEVER .NOT. CAT                                               2740
            CSUB = 33                                                        2750
            CAT = 1B                                                         2760
            OTHERWISE                                                        2770
            CSUB = 34                                                        2780
            END OF CONDITIONAL                                               2790
            TRANSFER TO CENTER                                               2800
CENTER      A(CSUB+CSIDE,CCNT) = NUWORD                                      2810
            TRANSFER TO RESET1                                               2820
           R  EQUIVALENCE DECOMPOSITION  ********************************   4380
           R                                  COMMA IN EQU
S(30)       CONTINUE
```

```
          WHENEVER NUWORD.E.$ $,TRANSFER TO RESET1
          WHENEVER .NOT. EPAR
              ESUB= 15
              EPAR=1B
          OR WHENEVER .NOT. EEL
            ESUB = 16                                                    4400
            EEL = 1B                                                     4410
            OR WHENEVER .NOT. EEID .AND. .NOT. E2NDPN                    4450
            ESUB = 17                                                    4460
            EEID = 1B                                                    4470
          OR WHENEVER .NOT. EAT .AND. E2NDPN                             4420
            ESUB = 18                                                    4430
            EAT = 1B                                                     4440
          END OF CONDITIONAL                                             4480
          TRANSFER TO EENTER                                             4490
         R                                    PERIOD IN EQU
S(31)     WHENEVER .NOT. EPAR, A(15,ECNT) = NUWORD                       4500
          EPAREN = 0
          E2NDPN=0B
          EPAR = 0B                                                      4510
          EEL= 0B                                                        4520
          EEID = 0B                                                      4530
          EAT = 0B                                                       4540
ECNTIC    ECNT=ECNT+1
          WHENEVER ECNT .G. 399                                          4570
          ECNT = ECNT -1                                                 4580
          PRINT COMMENT $0EQUIVALENCE TABLE LENGTH EXCEEDED$
          END OF CONDITIONAL                                             4610
          W'R PPER, T'O PERET
          TRANSFER TO RESET1                                             4620
         R                                    LEFT PAREN IN EQU
S(32)     CONTINUE
            WHENEVER EPAREN.E. 1, E2NDPN=1B
          EPAREN=1
          W'R NUWORD .E. $ $, T'O RESET1
          WHENEVER .NOT. EPAR                                            4640
            ESUB = 15                                                    4650
            EPAR = 1B                                                    4660
          OR WHENEVER .NOT. EEL                                          4670
            ESUB = 16                                                    4680
            EEL = 1B                                                     4690
          OR WHENEVER .NOT. EEID                                         4700
            ESUB = 17                                                    4710
            EEID = 1B                                                    4720
          END OF CONDITIONAL                                             4730
          TRANSFER TO EENTER                                             4740
         R                                    RIGHT PAREN IN EQU
S(33)     WHENEVER NUWORD .E. $ $, TRANSFER TO RESET1                    4750
          WHENEVER .NOT. EEL                                             4760
            ESUB = 16                                                    4770
          OR WHENEVER .NOT. EEID .AND..NOT. E2NDPN                       4780
            ESUB = 17                                                    4790
          OR WHENEVER .NOT. EAT                                          4800
            ESUB = 18                                                    4810
            EAT = 1B                                                     4820
          OTHERWISE                                                      4830
          ESUB = 19                                                      4840
          END OF CONDITIONAL                                             4850
          TRANSFER TO EENTER                                             4860
```

```
EENTER     A(ESUB, ECNT) = NUWORD                                          4870
           TRANSFER TO RESET1                                              4880
          R                                EQUAL SIGN IN EQU
S(34)        ESUB = 14                                                     4890
           TRANSFER TO EENTER                                              4900
          R
          R N = 0  STATEMENT COLLECTION        N = 4  ELEMENT DESCRIPTION  0170
          R N = 1  DESCRIPTION FINISHED        N = 5  NAME OF ELEMENT      0180
          R N = 2  PERMANENT                   N = 6   BROAD SCOPE PARA.   0190
          R N = 3  ANOTHER DESCRIPTION         N = 7  ATTACHMENT NAME      0200
          R S(36)  COMMA          S(39)  RIGHT PAREN                       0320
          R  S(37))   PERIOD      S(40)  EQUAL SIGN                        0330
          R S(38)   LEFT PAREN    S(41)   MORE THAN 6 CHARACTERS           0340
S(41)      DONE=0B
           W'R ABRSW .AND. DCNT .L. 4, T'O ABRINS
           DWORD(DCNT)=NUWORD
           DCNT = DCNT +1                                                  0370
           WHENEVER DCNT .G. 4                                             0380
           PRINT COMMENT $0(ELEMENT DESCRIPTION WORDY****)$
           IFERR2=1B
           TRANSFER TO NUSTAT
           END OF CONDITIONAL                                              0420
           TRANSFER TO RESET1
S(37)      CONTINUE                                                        0450
          R   PERIOD ENCOUNTERED                                           0460
           WHENEVER.NOT. DONE                                              0480
           DWORD(DCNT)= NUWORD
           LOW = 0                                                          490
           HIGH = 4                                                        0500
LISTA           THROUGH LISTA, FOR N= LOW, 1, (DWORD(0) .E.  PART1(N)      0510
          1                          .AND.   DWORD(1) .E. PART2(N))        0520
          2                          .OR.    N.G. HIGH                     0530
           WHENEVER N .G. HIGH                                             0540
LISTB      T'H LISTB, FOR N=LOW,1, ABR2(N) .E. DWORD .OR. N .G. HIGH
           W'R N .G. HIGH
           PRINT COMMENT $0INCORRECT STATEMENT OR SPELLING$
                         TRANSFERTO NUSTAT
           E'L
           END OF CONDITIONAL                                              0580
          R(**WHEN N IS LESS THAN OR EQUAL TO HIGH, STATEMENT TYPE
          R   IS DETERMINED.) IF N.LE. 4,STATEMENT NEEDS NO FURTHER SCAN
           DONE = 1B                                                       0610
           WHENEVER N.LE.4,TRANSFER TO S2(N)
           TRANSFER TO RESET1                                              0620
          R                                                                0640
           OTHERWISE                                                       0630
           DONE = 0B                                                       0650
          R(**TRANSFER TO STATEMENT    TYPE N. SEE ABOVE.*)
           TRANSFER TO S2(N)                                               0750
          R                                                                0760
          R                                                                0770
           END OF CONDITIONAL                                              0780
          R                                                                0790
          R                          N = 0       1        2        3       0800
           VECTOR VALUES PART1 = $STATEM$,$DESCRI$,$PERMAN$,$ANOTHE$,      0810
          1$ELEMEN$,$NAMEOF$,$BROADS$,$ATTACH$,$ $                         0830
          R     4        5        6        7                               0820
           VECTOR VALUES PART2=$NTCOLL$,$TIONFI$,$NT$,     $DESCRI$,
          1$DESCRI$,$LEMENT$,$OPEPAR$,$ENTNAM$                             0850
```

```
          V'S ABR2= $ST'N$ , $DS'D$ , $PR'T$ , $AN'S$ , $EL'N$ , $NM'T$
         1, $BR'S$ , $AT'S$ , $ $
         R    COMMA IN ELEMENT DESCRIPTION.                                  0870
S(36)     CONTINUE                                                          0880
          WHENEVER .NOT. DONE
         1, TRANSFER TO S(37)
          TRANSFER TO S2(N)                                                 0900
S(40)           WHENEVER .NOT. DONE                                         0910
         R    EQUAL SIGN ENCOUNTERED - STATEMENT TYPE NOT DETERMINED         0920
              LOW = 5                                                       0930
              HIGH =7                                                       0940
                DWORD(DCNT)= NUWORD
         R  USE THE SAME SEARCH AS WHEN A PERIOD IS ENCOUNTERED             0950
              TRANSFER TO LISTA                                             0970
          END OF CONDITIONAL                                                0980
          PRINT COMMENT $OILLEGAL EQUAL SIGN ABOVE****$
          TRANSFER TO NUSTAT
         R LEFT OR RIGHT PAREN ENCOUNTERED IN ELEMENT DESCRIPTION           1030
S(38)     CONTINUE                                                          1040
S(39)     PRINT COMMENT $OPARENTHESIS IMPROPERLY USED IN ELEMENT DESCRI
         1PTION$
          TRANSFER TO NUSTAT
         R                                                                  1090
         R                    DESCRIPTION FINISHED.                         1100
S2(1)     CONTINUE                                                          1110
         R                                ANOTHER DESCRIPTIONS FOLLOWS      1130
S2(3)     NOSC(7)  = ELNAME                                                 1140
          P'T DWORDA, NOSC...NOSC(9)
          VECTOR VALUES NOSC=$NO STATEMENT COLLECTIONS INCLUDED WITH $,     1160
         1$ $,   $ DESCRIPTION$                                             1170
         R                    GO TO DESCRIPTION FINISHED AFTER A STATEME-   1180
         R                    MENT COLLECTION.                              1190
          SK=2
          TRANSFER TO FINISH
         R                    NEW ELEMENT DESCRIPTION FOUND BEFORE LAST     1210
         R                    ONE FINISHED                                  1220
         R                                                                  1230
S2(4)     PRINT COMMENT $ONEW DESCRIPTION BEGUN BEFORE LAST ONE FINISHE
         1D$
          SK=2
          TRANSFER TO FINISH
         R                                                                  1300
         R                                                                  1270
         R                    PERMANENT.   ENCOUNTERED WITHIN ELEMENT       1280
         R                    DESCRIPTION                                   1290
         R              ELEMENT DESCRIPTION IS ASSUMED TEMPORARY UNLESS     1310
         R              STATED PERMANENT                                    1320
S2(2)           WHENEVER TELCNT .E. 1                                       1330
          TELCNT = 0                                                        1350
          PELCNT = PELCNT +1                                                1360
                OTHERWISE                                                   1370
          PRINT COMMENT $OPERMANENT ELEMENT CANNOT FOLLOW TEMPORARY ELE
         1MENT$
                END OF CONDITIONAL                                          1410
          TRANSFER TO NUSTAT
         R                                                                  1430
         R                    ELEMENT NAME.                                 1440
S2(5)     ELN(PELCNT + TELCNT) = NUWORD                                     1450
          ELNAME = NUWORD                                                   1480
```

```
          P'T $S110,C6,HA    **********A*$,ELNAME
          TELCNT = TELCNT +1                                              1490
         R                    ELEMENT IS ASSUMED TO BE TEMPORARY         1500
         R                                                               1510
          TRANSFER TO NUSTAT                                             1520
         R                                                               1530
         R                    BROAD SCOPE PARAMETER.                     1540
S2(6)     EXECUTE BSPARM.                                                1550
          TRANSFER TO NUSTAT
         R                                                               1580
         R                                                               1600
         R                    ATTACHMENT NAME STATEMENT.                 1590
S2(7)     ATS(ATTCNT)= NUWORD                                            1630
          ATTCNT = ATTCNT +1                                             1640
          WHENEVER ATTCNT .G. 20                                         1650
          ATTCNT = 20
          PRINT COMMENT $0ATTACHMENT NAME LIST EXCEEDS TWENTY$
          END OF CONDITIONAL                                             1680
          TRANSFER TO NUSTAT
         R                    STATEMENT COLLECTION N=0                   1700
         R                                                               1710
S2(0)     CONTINUE                                                       1720
          TRANSFER TO NUEND(NUSCAN.(NUCHAR,NOATS))
         R      RESETS FOR ELEMENT DESCRIPTION RETURNS                   4200
         R                                                               4210
FINISH    CONTINUE
           TRANSFER TO NUEND(ENDDES.(0,NOATS))
NUEND(0)  CONTINUE
NUEND(1)  CONTINUE
          TRANSFER TO NXTSET
         R(**RETURN TO DECLARATION SECTION**)
NUEND(2)  CONTINUE
          WHENEVER NUCHAR .E. $.$
          I = 72
          OTHERWISE
          I = -1
          END OF CONDITIONAL
          K1=0
         R(**OTHERWISE REMAIN IN THE ELEMENT DESCRIPTION SECTION    **)
NUEND(3)  CONTINUE
NUSTAT    DCNT = 0                                                       4320
          HOLCNT = 1                                                     4330
          NUWORD = $ $                                                   4340
          TRANSFER TO LOOP                                               4350
         R
         R                    ** COMPILOR CONTROL CARDS **
         R
          VECTOR VALUES DKIND1=$ELEMEN$,$INPUTP$,$SYNONY$,$CONNEC$,$DES  2080
         1IRE$, $FUNCTI$ ,$NEWELE$,$CALCUL$,$NEXTSE$,$CHECKO$           2090
         2 ,$CHECKR$,$CONNEC$,$SYNONY$,$CALCUL$                         2100
         3 ,$SAVETA$ ,$EQUIVA$                                          2110
         4,$SUBSTI$,$CONFIG$
          VECTOR VALUES DKIND2=$DESCRI$,$RAMETE$,$S$,$IONS$,$RESULT$     2120
         1 , $NSUBST$ ,$ENTTAP$,$TIONS$,$OFDATA$,$T$                    2130
         2 ,$N$,$ION$,$ $,$TION$                                        2140
         3 ,$E$ ,$ENCE$                                                 2150
         4,$UTIONS$,$RATION$
          V'S ABR1=$EL'N$ , $IN'S$ , $SN'S$ , $CN'S$ , $DS'S$ , $FN'S$
         1, $NW'E$ , $CL'S$ , $NX'A$ , $CH'T$ , $CH'N$ , $CN'N$ , $SN'M
```

```
2$ , $CL'N$ , $SV'E$ , $EQ'E$ , $SB'S$ , $CN'O$
R                    CALCULATIONS ON TAPE THREE
R                    PROLOGUE ON TAPE FOUR
R                    FUNCTION DICTIONARY.                                R       1
R   CONNEC. INPTPR. EQUIVN. SYNONM. SUBSPT.    (IN BUFFER DECK)R       2
RCONCK.  EQVGEN. INPUT.  INSRTC. OCTDEC.                         R       3
R   OUTPUT. PLACE.  PROLOG. SEQPGM. SYNELM.                      R       4
R  SAVET4. SYSTEM. SETEOF. SSORDR. IPRELM.                       R       5
R                                                                R       6
R                    TEMPORARY ROUTINES IN CORE1.
R   (CONCK. )  (SAVET4.)
R(MAIN) FOR FIRST CORE                                                   0010
RINPUT FOR CONNECTIONS, SYNONYMS, INPUT-                                 000
RPARAMETERS, DESIRED RESULTS AND DECLARATIONS                            0020
R
 PROGRAM COMMON INDEX(99),A,CH
 NORMAL MODE IS INTEGER                                                  0070
 DIMENSION B(12)
  DIMENSION WORD(11),
1S(42,DIMS),  DWORD(4), PNUM(1), AMB(7),CH(71)
 DIMENSION BIT(1),DCNT(4),EQER(9),PART1(7),PART2(7),PART(7)
1           ,S2(8),TYPE(7)
2           ,BITS(80,DIM3),MAD(50)
 DIMENSION SBIT(1),SCOPB1(1),ATS(20),EQUER(9)
 DIMENSION PELT(300),ELN(95),FPAR(71),ZPAR(69)
 DIMENSION A(15899,DIM1),PCNT(1)
 DIMENSION SBIT(1)
 VECTOR VALUES THREE= 3
 VECTOR VALUES FOUR = 4
 VECTOR VALUES DIMS = 2,7,6
 VECTOR VALUES DIM1 = 2,401,400                                          0030
 VECTOR VALUES DIM3=2,5,4
 VECTOR VALUES A(15600)=$ELTAPE$
 EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),
1            ( A(15603),PARCNT ),( A(15604),ELN    ),
2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),
3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),
4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),
5            ( A(15843),SCNT   ),( A(15844),ECNT   ),
6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),
7            ( A(15848),ID1    ),( A(15849),ID2    ),
8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )
9           ,( A(15853),DIM1) ,(A(15889),FIVE)
 EQUIVALENCE ( A(15856),CKRN   ),( A(15857),THREE  )                     E       1
1,            (A(15858),FOUR   ),(A(15859),CLDONE)
 EQUIVALENCE(A(15870),B),(A(15860),NUWORD),(A(15861),SBIT)
 EQUIVALENCE(A(8000),BITS),(A(8080),ATS),(A(8100),MAD)
1           ,(ELTPOK,TAPEOK),(ATTCNT,NOATS)
2           ,(T4,FOUR),(SCRAP, FIVE)
 EQUIVALENCE (A(15891),ELNAME)
 EQUIVALENCE (PELT,A(8200))
 DIMENSION ELNAME(1)
 EQUIVALENCE (A(15890),NUCHAR)
 DIMENSION VCK(10)
 EQUIVALENCE (A(15900),VCK)
 EQUIVALENCE ( TIME,A(15999))
 BOOLEAN ABRSW
 BOOLEAN PEQL
 BOOLEAN PPER
```

```
 BOOLEAN PEID
 BOOLEAN CLDONE
 BOOLEAN CAT,CEL,CTO,CEID,PLP1,                                          0110
1PLP2, PEL, PAT, IFERR1, IFERR2, TAPEOK, OUT, FEL, FSN                   0120
2 ,CLC    , NTAPE, EOFB , SET4,    CKRN                                 0130
 BOOLEAN EPAR, EEL, EEID, EAT, E2NDPN                                    0140
 BOOLEAN SPAR, SEL, SEID, SAT, S2NDPN, S1STEQ                            0160
 BOOLEAN FSNEW,FSOLD, FSEL                                               0190
 BOOLEAN CPABLE,DONE,EQUAL,ELTPOK,PAREN,THEN
 BOOLEAN NUELTP                                                    B      4
 BOOLEAN ALLSET, PERIOD
 BOOLEAN WITH
 END OF PROGRAM                                                          *
```

```
$COMPILE MAD,PUNCH OBJECT,PRINT OBJECT                                  BSPARM00
          EXTERNAL FUNCTION
          R'N
          ENTRY TO BSPARM.
          I = LOCATE.(NUWORD, FPAR, PARCNT)
          WHENEVER I.L. 0
         R                  (PARAMETER IS NOT ON F-PAR LIST YET.)
          I = PARCNT
          J= I/36
          SBIT(J)= INBIT.(SBIT(J),I-J*36,1)
          EXECUTE PARCK.(I)
         R(**PARCNT IS INCREMENTED IN PARCK. SUBROUTINE.)
         R                  (SBIT IS TEMPORARY SCPE BIT FOR THE ELEM.)
          OTHERWISE
               J= I/36
               I= I-J*36
                  WHENEVER .NOT. IFBIT.(SCOPB1(J),I)
                    PREV = NUWORD
          P'T FOMAT,PREV...PREV(7)
          OTHERWISE
                    SBIT(J)= INBIT.(SBIT(J),I,1)
          END OF CONDITIONAL
          END OF CONDITIONAL
          VECTOR VALUES PREV=$ $,$ IS NARROW SCOPE BY PREVIOUS ASSERTIO
         1N.$
          FUNCTION RETURN
         R                   ******COMPILER CONTROL CARDS****
          PROGRAM COMMON A
          V'S FOMAT=$1H0,22C6*$
          DIMENSION A(15999),SBIT(1),SCOPB1(1), FPAR(71),ZPAR(69)       D       1
          NORMAL MODE IS INTEGER
          EQUIVALENCE(A(15700),FPAR)  ,(FPAR(70),SCOPB1)                E       1
         1       ,(A(15603),PARCNT),(A(15861),SBIT)
         2       ,(A(15860),NUWORD),(A(15772),ZPAR)
          BOOLEAN IFABIT.
          BOOLEAN IFBIT.
          END OF FUNCTION                                                       *
```

```
$COMPILE MAD,PUNCH OBJECT,PRINT OBJECT                                  CONCK000
          EXTERNAL FUNCTION
          R'N
         R  CHECK FOR AMBIGUOUS OR REDUNDENT CONNECTIONS **************      4920
         R  EXECUTE BEFORE CORE CHANGE AND AFTER EOF1                       4930
          ENTRY TO CONCK.                                                   4940
          THROUGH CK,FOR VALUES OF CKA=0,4                                  4950
          THROUGH CK, FOR CKB=0,1,CKB.GE. CCNT
          WHENEVER A(33+CKA,CKB).E.$ $,A(33+CKA,CKB)=$1$                    4970
          THROUGH CK, FOR CKC=0,4,CKC.G. 4.OR. CKA .GE. 4
          THROUGH CK, FOR CKD= CKB+1,1, CKD.GE. CCNT
          THROUGH CK3, FOR CKI=0,1, CKI.GE. 4
          WHENEVER A(31+CKA+CKI,CKB).NE.A(31+CKA+CKI+CKC,CKD),TRANSFER      5010
         1 TO CK                                                            5020
          WHENEVER CKI.E.3, EXECUTE CKPRNT.                                 5021
CK3       CONTINUE                                                          5030
          THROUGH CK4, FOR CKI=0,1, CKI.GE. 4
          WHENEVER A(35+CKI-CKA,CKB).NE. A(35+CKI-CKA-CKC,CKD)              5050
          P'T FORM,CKB,CKD
          V'S FORM=$H*0INCONSISTENT CONNECTION LINES- *,2I6*$
          IFERR1=1B                                                         5100
          TRANSFER TO EQIN                                                  5110
          END OF CONDITIONAL                                                5120
CK4       CONTINUE                                                          5130
EQIN      CCNT=CCNT-1                                                       5140
          P'T FORM1,CCNT
          V'S FORM1=$H*0CCNT LOWERED TO *,I6*$
          THROUGH CK5, FOR CKI=31,1, CKI.GE. 39
CK5       A(CKI,CKD)=A(CKI,CCNT)                                            5160
CK        CONTINUE                                                          5170
          FUNCTION RETURN                                                   5180
          INTERNAL FUNCTION
                                ENTRY TO CKPRNT.
          P'T FOMAT,CK1A...CK1A(4)
          EXECUTE DPRINT.($COUNTS$,CKA,4)
          FUNCTION RETURN
          END OF FUNCTION
          VECTOR VALUES CK1A=$ $,$CKA$,$CKB$,$CKC$,$CKD$
          EQUIVALENCE (V(0),CKA),(V(1),CKB),(V(2),CKC),(V(3),CKD)
                                DIMENSION V(4)
         R    ***COMPILER CONTROL CARDS    ********
         R  DEFINITION OF  A(39,0)...A(39,399)
          VECTOR VALUES A(15600)=$ELTAPE$
          EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),
         1            ( A(15603),PARCNT ),( A(15604),ELN    ),
         2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),
         3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),
         4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),
         5            ( A(15843),SCNT   ),( A(15844),ECNT   ),
         6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),
         7            ( A(15848),ID1    ),( A(15849),ID2    ),
         8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )
         9           ,( A(15853),DIM1)
          EQUIVALENCE (PELT,A(8200))
          VECTOR VALUES DIM1 = 2,401,400                                    -030
          NORMAL MODE IS INTEGER                                            0070
          DIMENSION A(15999,DIM1),PCNT(1)
          BOOLEAN IFERR1, TAPEOK
          PROGRAM COMMON A
```

```
 V'S FOMAT=$1HO,22C6*$
 DIMENSION PELT(300),ELN(95),FPAR(71),ZPAR(69)
R
 END OF FUNCTION                                                    *
```

```
$ASSEMBLE,PUNCH OBJECT                                          DP-PACK0
        ENTRY   DFMP,DFDP,DPFSB,DPFAD,DPFDP,DPFMP
DFMP    CALL    ERROR
DFDP    EQU     DFMP
DPFSB   EQU     DFMP
DPFAD   EQU     DFMP
DPFDP   EQU     DFMP
DPFMP   EQU     DFMP
        END                                                                *
```

```
$ASSEMBLE,PUNCH OBJECT                                          IFINBIT0
        ENTRY INBIT
        ENTRY IFBIT
INBIT   SLN     1   RSLT = INBIT.(WORD,J,BIT)
        CLA 3,4     THE VALUE OF BIT  PLACED IN THE JTH POSITION OF WORD.
        STA BIT
        SLT 1
IFBIT   SLN 1
        SXD XRA,1
        CLA 2,4
        STA *+1
        LXA **,1
        CLA 1,4
        STA WORD1
        STA WORD2
        CAL MASK1
        SLT 1
XRA     TXL BIT,0,0
        ALS 35,1
WORD1   ANA **
        TZE EXIT+1
        CLA MASK1
        TXL EXIT+1,0,0
BIT     ANA **
        SLW COMMON
WORD2   CAL **
        LRS 35,1
        ANA MASK2
        ORA COMMON
        LLS 35,1
        SLW COMMON
EXIT    CLA COMMON
        LXD XRA,1
        TRA 3,4
MASK1   OCT 000000000001
MASK2   OCT -377777777776
COMMON  SYN -1
LAST    BSS 0
        END                                                              *
```

```
$ASSEMBLE,PUNCH OBJECT                                          INPUT000
        ENTRY INPUT
INPUT   CLA     1,4             EXECUTE INPUT.(CH...EOFLBL,WORD)
        STD     EOFA            EOFLBL
        ADD     INPUT           ADD ONE
        STA     CHA             CH
        CLA     2,4
        STA     WORDA
        SXD     XRC,4
        CALL    SCARDS          READ ONE CARD
EOFA    TIX     B,0,**
        CALL    SPRINT          PRINT ONE CARD
        TIX     B-1,0,13
        AXT     0,2
        AXT     72,1
NEXT    AXT     6,4
        CAL     B+11,2                NEXT WORD FROM B REGION
SPLIT   LDQ     BLNK
        LGR     6
CHA     STQ     **,1            CH+1 WILL BE IN ADDRESS.
        TXI     *+1,1,-1
        TIX     SPLIT,4,1       CONUNTS LETTERS.
        TXL     OUT,1,1
        TXI     NEXT,2,1
OUT     AXT     0,1             PUTCARD INTO WORD REGION
        AXT     12,2
WM      CLA     B+12,2
WORDA   STO     **,1
        TXI     *+1,1,1
        TIX     WM,2,1
        LXD     XRC,4           RETURN
        TRA     3,4
XRC     PZE     0,,**
BLNK    BCD 1
B       BSS 14
        END
```

```
$ASSEMBLE,PUNCH OBJECT                                          INSRTC00
        ENTRY INSRTC
        ENTRY EXTRC
INSRTC  SLN 1          RSLT = INSRTC.(WORD, J, CHAR)
        CLA     3,4      CHAR IS PLACED IN THE JTH POSITION OF WORD.
        STA CHAR
        SLT 1
EXTRC   SLN 1          RSLT = EXTRC. (WORD, J)
        SXD XRB,2      RSLT IS THE CHARACTER EXTRACTED FROM THE JTH
        CLA*    2,4
        PAX     0,2
        CAL*    1,4
        SLT 1
XRB     TXL IN1,0,0
        LDQ BLANKS
BACK1   TXH OUT1,2,5
        ARS 6
        TXI BACK1,2,1
OUT1    LGL 30
        SLW COMMON
        TXL EXIT,0,0
IN1     SLW COMMON
CHAR    LDQ **
        CAL MASK
        RQL 6
COUNT   TXH OUT2,2,5
        ALS 6
        TXI COUNT-1,2,1
OUT2    STQ COMMON-1
        COM
        ANS COMMON
        COM
        ANA COMMON-1
        ORS COMMON
EXIT    CLA COMMON
        LXD XRB,2
        TRA 3,4
BLANKS  BCD 1
MASK    OCT 000000000077
COMMON  SYN -1
LAST    BSS 0
        END                                                     *
```

```
$COMPILE MAD,PUNCH OBJECT,PRINT OBJECT                                  IPRELM00
          EXTERNAL FUNCTION
          R'N
          ENTRY TO  IPRELM.                                                      0370
         R SET UP BIT PATTERNS FOR DESIRED RESULTS AND INPUT PARAMETERS          0010
         R                                                                        20
         R        BRIEF DESCRIPTION OF IPRELM (INPUT PARAMETER-DESIRED          0030
         R   RESULT ELEMINATION). THE LIST OF PARAMETERS IS SEARCHED            0040
         R    FOR THE PARAMETER ON THE INPUT PARAMETER LIST.  WHEN THE          0050
         R     PARAMETER IS KNOWN, THE CONNECTION MATRIX IS THEN                 0060
         R     SEARCHED UNTIL A ROW IN THE CONNECTION MATRIX MATCHES             0070
         R     THE ROW IN THE INPUT PARAMETER LIST.  A BIT IS PLACED IN          0080
         R/A/, WHICH CODES THE ROW OF THE CONNECTION MATIIX WITH                 0090
         R THE LOCATION OF THE PARAMETER ON THE PARAMETER LIST                  0100
         R     THE SAME PROCESS IS REPEATED FOR THE DESIRED RESULT LIST         0110
          PROGRAM COMMON A                                                      0120
          V'S FOMAT=$1H0,22C6*$
          DIMENSION A(15999,DIM1), ERR(8)                                       0130
          VECTOR VALUES DIM1 = 2,401,400                                        0140
           DIMENSION PCNT     (1)                                               0170
         R
          BOOLEAN OCCURS
         R  DEFINITION OF  A(39,0)...A(39,399)                                  0180
          VECTOR VALUES A(15600)=$ELTAPE$                                       0190
          EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),                  0200
         1            ( A(15603),PARCNT ),( A(15604),ELN    ),                  0210
         2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),                  0220
         3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),                  0230
         4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),                  0240
         5            ( A(15843),SCNT   ),( A(15844),ECNT   ),                  0250
         6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),                  0260
         7            ( A(15848),ID1    ),( A(15849),ID2    ),                  0270
         8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )                   0280
          DIMENSION PELT(300),ELN(95),FPAR(71),ZPAR(69)                         0290
          NORMAL MODE IS INTEGER                                                0300
          BOOLEAN IFERR1                                                        0310
          EQUIVALENCE (A(12400),A31),(A(12800),A32),(A(13200),A33),             0320
         1(A(13600),A34),(A(14000),A35),(A(14400),A36),(A(14800),A37),          0330
         2(A(15200),A38)   ,(A(15600),A39)                                      0340
          DIMENSION A31(1),A32(1),A33(1),A34(1),A35(1),A36(1),A37(1),           0350
         1A38(1)   ,A39(1)                                                      0360
          DIMENSION FPAR(70)
          DIMENSION CHECK(2)
          EXECUTE PLACE.( A(23,0), 3200,0)                                      0390
         R                  COLUMN 4 - INPUT PARAMETERS                        0400
          COL = 4                                                               0410
          THROUGH LISTS, FOR VALUES OF K=23,25                                  0420
          WHENEVER K.E.25,COL=9                                                 0450
          THROUGH LISTS, FOR I=0,1,I.GE. PCNT(K/25)                             0460
LOOPA     THROUGH LOOPA, FOR J=0,1,  J .GE. PARCNT .OR. A(COL,I) .E.            0470
         1FPAR(J)
          WHENEVER J.E.PARCNT                                                   0490
          VECTOR VALUES ERR  = $UNKNOWN PARAMETER AT$                           0500
          ERR(4) = A(COL,I)                                                     0510
          ERR(5) = A(COL+1,I)                                                   0520
          ERR(6) = A(COL+2,I)                                                   0530
          ERR(7) = A(COL+3,I)                                                   0540
          ERR(8) = A(COL+4,I)                                                   0550
          P'T FOMAT,ERR...ERR(8)
```

```
          IFERR1 =1B                                                          0570
          TRANSFER TO LISTS                                                   0580
          END OF CONDITIONAL                                                  0590
          TEL    = A(COL+1,I)                                                 0600
          TEID   = A(COL+2,I)                                                 0610
          TAT    = A(COL+3,I)                                                 0620
          TAID   = A(COL+4,I)                                                 0630
           OCCURS = 0B                                                         631
          THROUGH LISTS1, FOR L=0,1,L.GE. CCNT
          WHENEVER  (TAID.E.A34(L)     .OR.  TAID .E. $ $ )                   0690
         1.AND. ( TAT .E. A33(L)       .OR.  TAT  .E. $ $ )                   0700
         2.AND. ( TEID.E. A32(L)       .OR.  TEID .E. $ $ )                   0710
         3.AND. ( TEL .E. A31(L)       .OR.  TEL  .E. $ $ )                   0720
         R                                                                     740
          JMOD = J/36                                                         0750
          A(K+JMOD,L) = INBIT.(A(K+JMOD,L),J-JMOD*36, 1)                      0760
          OCCURS = 1B                                                         0770
          END OF CONDITIONAL                                                  0790
          WHENEVER  (TAID.E. A38(L)     .OR. TAID .E. $ $ )                   0800
         1    .AND.  (TAT .E. A37(L)     .OR. TAT  .E. $ $ )                   0810
         2    .AND.  (TEID.E. A36(L)     .OR. TEID .E. $ $ )                   0820
         3.AND. (TEL .E. A35(L)       .OR.  TEL  .E. $ $ )                   0830
          JMOD = J/36                                                         0840
          A(K+JMOD,L) = INBIT.(A(K+JMOD,L),J-JMOD*36, 1)                      0850
          OCCURS = 1B                                                         0880
          END OF CONDITIONAL                                                  0890
LISTS1     CONTINUE
          W'R .NOT. OCCURS, P'T FOMAT,NO...NO(9)
LISTS     CONTINUE                                                             900
          VECTOR VALUES NO(5) = $DOES NOT OCCUR ON CONNECTION LIST$           0920
          EQUIVALENCE (NO,TEL),(NO(1),TEID),(NO(2),TAT),(NO(3),TAID)          0930
          EQUIVALENCE (PELT,A(8200))
          FUNCTION  RETURN                                                    0940
          END OF FUNCTION                                                      *
```

```
$ASSEMBLE,PUNCH OBJECT                                          LOCATE00
        ENTRY LOCATE
LOCATE  CLA*    3,4             LOCATE,(WORD, LIST, COUNT)
        ADD     ONE
        PAX     0,2
        CLA     2,4             LIST ADDRESS PLUS ONE
        STA     COMP2
        ADD ONE
        STA     COMP
        CLA*    1,4             WORD
COMP2   CAS     **
        TRA     COMP
        TRA     FIRST
COMP    CAS     **,2
        TIX     *-1,2,1
        TRA     EQUAL
        TIX     *-3,2,1
EQUAL   PXA     0,2             WORD FOUND AT THIS LOCATION PLUS 1
        SUB     ONE             IF WORD NOT ON LIST ACCUMULAROR WILL BE NEG
        TNZ     4,4
        SUB     ONE
        TRA     4,4
FIRST   CLA     ZERO
        TRA     4,4
ZERO    PZE     0
        TRA     4,4
ONE     PZE  1
        END                                                     *
```

```
$ASSEMBLE,PUNCH OBJECT                                          LOGIC.00
        ENTRY AND
        ENTRY NOT
        ENTRY OR
        ENTRY XOR
        ENTRY THEN
        ENTRY EQV
HOOK    CAL*    2,4
        SLW     C-2
HOOK1   CAL*    1,4
        SLW C-1
        TRA 1,2
EQV     TSX HOOK,2
        ORA C-2         W1.OR.W2
        COM             .NOT. (W1.OR.W2)
        SLW C
        CAL C-1
        ANA C-2         W1.AND.W2
        ORS C           (W1.AND.W2).OR.(.NOT.(W1.OR.W2))
        TRA R2
THEN    TSX HOOK,2
        COM             .NOT.W1
        ORA C-2         .NOT.W1.OR.W2
        TRA R1
XOR     TSX HOOK,2
        ANA C-2         W1.AND.W2
        COM             .NOT.(W1.AND.W2)
        SLW C
        CAL C-1
        ORA C-2         (W1.OR.W2)
        ANS C           (W1.OR.W2).AND.(.NOT.(W1.ANDW2)
        TRA R2
NOT     TSX HOOK1,2
        COM             NOT.W1
        TRA R1
OR      TSX HOOK,2
        ORA C-2         W1.ORW2
        TRA R1
AND     TSX HOOK,2
        ANA C-2         W1 AND W2
R1      SLW C
R2      CLA C
        TRA 2,4
LAST    BSS 0
C       SYN -1
        END                                                     *
```

```
$COMPILE MAD,PUNCH OBJECT,PRINT OBJECT                          LPRINT00
            EXTERNAL FUNCTION(HEAD, LIST, COUNT)
            R'N
            ENTRY TO DPRINT.
            K=12
            P'T FOMAT,HEAD
            THROUGH B, FOR I=0,12, I.GE. COUNT
            WHENEVERCOUNT-I.LE. 12, K= COUNT -I
            THROUGH C, FOR J=I,1, J.GE. K
 C          LINE(J) = LIST(J)
B           P'T FOMAT,LINE(I)...LINE(I+K-1)
            FUNCTION RETURN
            NORMAL MODE IS INTEGER
            DIMENSION LINE(12)
            PROGRAM COMMON A
            V'S FOMAT=$1H0,22C6*$
            DIMENSION A(15999)
            EQUIVALENCE (A(15858), FOUR),(A(15601), PELCNT),
           1            (A(15602),TELCNT),(A(15603),PARCNT)
            EQUIVALENCE(A(15700),FPAR),(A(15772),ZPAR )
           1,(A(15604),ELN)
            END OF FUNCTION                                                *
```

```
$ COMPILE MAD,PUNCH OBJECT,PRINT OBJECT                                NUSCAN00
          EXTERNAL FUNCTION(      ARG1,ARG2)
          R'N
          ENTRY TO NUSCAN.
          NUCHAR=ARG1
          NOATS = ARG2
          IFERR2 = 0B
          CPABLE = 0B
          MADCNT = 0
          SCCNT = 0
          PERIOD = 0B
          PAREN = 0B
          ALLSET = 0B
          THEN = 0B
          SAT = 0B
          WITH = 0B
          EOFB = 0B
          DWORD = $ $
          NOATT = $ $
          BIT(0) = 0
          BIT(1) = 0
          J = 0
          TRAP = 0B
          BOOLEAN TRAP
           TRAP1= 1B
          BOOLEAN TRAP1
          ABRSW=0B
          BOOLEAN ABRSW
          W'R CKRN
          PRINT COMMENT $ONUSCAN$
          E'L
         R                    SCAN USED IN STATEMENT COLLECTIONS.          1740
         R                                                                 1750
          EXECUTE PLACE.(BITS,80,0)
          WHENEVER NUCHAR.NE. $.$,TRANSFER TO CARDIN
         R(** IF ABOVE IS TRUE8 THE NEXT CARD IS ALREADY IN CORE.
READ2     EXECUTE INPUT.(CH...END1, WORD)                                 1760
          W'R CH .E. $1$
          CPABLE=0B
          TRAP1=1B
          E'L
CARDIN    CONTINUE
          HOLCNT = 1
          NUWORD = $ $
          DCNT = 0
          WHENEVER CH .E. $/$, TRANSFER TO READ2                          1770
          THROUGH STMNT, FOR SI = 0,1, SI .G. 71                          1780
 SCPCN1   CONTINUE
          NUCHAR = CH(SI)                                                 1790
          W'R SI.E.0 .AND .NUCHAR .E.$1$
          NUCHAR = $ $
          CPABLE = 0B
           TRAP1= 1B
          E'L
          WHENEVER NUCHAR .E. $ $, TRANSFER TO STMNT                      1800
 SCPCNT   T'H  SCPCNT, FOR SKK = 0,1,NUCHAR.E.PUNCT(SKK).OR.SKK.G.4
         R(**PUNCT LIST IS , . ( ) =
          W'R SKK.E.1, TRAP1 = 0B
          W'R SKK .LE.3
```

```
          W'R SKK.E.3, TRAP1 = 1B
                WHENEVER .NOT. CPABLE, TRANSFER TO PART(SKK)
                 TRANSFER TO TYPES
         R                                                              1940
         R                                                              1950
          O'R SKK.E.4
          TRAP1 = 0B
                TRANSFER TO MADOUT                                      1980
         R                                                              1990
          OTHERWISE                                                     2000
          NUWORD = INSRTC.(NUWORD,HOLCNT,NUCHAR)                        2010
                HOLCNT = HOLCNT+1                                       2020
          W'R NUCHAR .E. $'$
          ABRSW=1B
          O'R ABRSW
          ABRSW=0B
          HOLCNT=7
          E'L
                       WHENEVER HOLCNT.G. 6                             2030
          W'R CKRN
          W'R TRAP1,  PRINT COMMENT $OTRAP17$
          E'L
          TRAP = 1B
                       DWORD(DCNT) = NUWORD                             2040
                       DCNT = DCNT +1                                   2050
                             SI=SI+1                                    2070
                       NUWORD  = $ $                                    2080
                       HOLCNT = 1                                       2090
                    WHENEVER .NOT. CPABLE, TRANSFER TO TYPEC
                     TRANSFER TO TYPES
                 END OF CONDITIONAL                                     2100
          END OF CONDITIONAL                                            2110
          TRANSFER TO STMNT                                             2120
         R                                                              1870
         R                                                              1880
TYPES       THROUGH TYPES, FOR SK=0,1,(STYPE1(SK).E.DWORD(0))
         2                    .OR. SK .G. 2                             1910
          W'R SK .G. 2
ABRF1     T'H ABRF1, FOR SK=0,1, ABR(SK) .E. DWORD .OR. SK .G. 2
          E'L
          W'R SK.E.0
          TRAP1 = 1B
          W'R CKRN
          PRINT COMMENT $OTRAPSK$
          E'L
          OTHERWISE
          TRAP1 = 0B
          E'L
                WHENEVER SK.G. 2, TRANSFER TO MADOUT
          W'R SK.E.1
          NUCHAR = $.$
          TRAP1 = 0B
          E'L
                TRANSFER TO FINISH
         R                                                              2130
         R                                                              2140
         R                        SK = 0        1        2             2150
          VECTOR VALUES STYPE1=$STATEM$,$DESCRI$,$ANOTHE$,$ $,
         1$ESTIMA$,$COMPUT$,$WITHOU$                                    2180
```

```
          1,$ELEMEN$
          R      4         5       6                                                    2170
           VECTOR VALUES STYPE2=$NTCOLL$,$TIONFI$,$DESCRI$                             2190
          R                                                                            2200
          R                      CAPABILITY STATEMENT, COMMA ENCOUNTERED               2240
           V'S ABR=$ST'N$ , $DS'D$ , $AN'S$ , $ $ , $ES'E$ , $CM'E$ ,
          1$WT'T$ , $EL'N$
PART(0)       CONTINUE                                                                 2250
           W'R TRAP.AND.TRAP1
           TRAP = 0B
           NUWORD = DWORD(0)
           DCNT = 0
           DWORD(0) = $ $
           W'R SKK.E.2, T'O PARNAM
            T'O TRAPED
           E'L
           WHENEVER NUWORD . E. $ $                                                    2270
           TRANSFER TO RESET2
           OR WHENEVER NUWORD .E. $THEN$                                               2280
                 THEN = 1B                                                             2290
                TRANSFER TO NUSTA2
          R                      CHECK ESTIMATE, COMPUTE, AND WITHOUT 4 5 6           2300
           OTHERWISE
TYPEC      T'H TYPEC, FOR JK=4,1, STYPE1(JK) .E. DWORD .OR. JK .G. 6
           W'R JK .LE. 6
           SI=SI+1
           W'R JK .E. 4, SI=SI+1
SCAN       T'H SCAN, FOR SKK=0,1, SKK .G. 4 .OR. CH(SI) .E. PUNCT(SKK)
           W'R SKK .G. 4, SI=SI-1
           TRAP1=0B
           DCNT=0
           THEN=1B
           DWORD=0
           T'O PART(JK)
           E'L
ABRF2      T'H ABRF2, FOR JK=4,1, ABR(JK) .E. DWORD .OR. JK .G. 6
           W'R JK .LE. 6, T'O SCAN
           W'R CPABLE, T'O TYPES
           W'R NUCHAR .NE. $,$, T'O SCPCN1
           END OF CONDITIONAL
           W'R TRAP.AND. TRAP1
           NUWORD = DWORD(0)
           DCNT = 0
           TRAP = 0B
           E'L
           WHENEVER .NOT. PAREN
          R                      A PARAMETER NAME IN CAPABILITY STATEMENT             2420
PARNAM     CONTINUE
           SAT= 0B
           WHENEVER NUWORD.E.$ $, TRANSFER TO RESET2
 TRAPED      CONTINUE
           W'R CKRN
           W'R TRAP1, PRINT COMMENT $0TRAPED$
           E'L
                          J=PARCK.(J)                                                  2430
                    JMOD = J/36                                                        2460
                    BIT(JMOD) = INBIT.( BIT(JMOD), J-36*JMOD, 1)                       2470
          R                                                                            2480
           OTHERWISE                                                                   2490
```

```
          R(** AN ATTACHMENT NAME**)
ATTNAM     CONTINUE
           W'R NUWORD .E. $ $.AND..NOT.TRAP,T'O RESET2
           W'R TRAP .AND. DWORD(0) .E. $ $
           TRAP = 0B
           T'O RESET2
           E'L
           WHENEVER SAT
          R                    AN ATTACHMENT NAME FOLLOWED BY AN IDENTIFIER   2500



           BITS(IAT,1)=INBIT.(BITS(IAT,1),35,1)



           SAT=0B
           OTHERWISE
           SAT=1B
           W'R TRAP
           I = LOCATE.(DWORD(0),ATS,NOATS)
           TRAP = 0B
           OTHERWISE
                 I = LOCATE. (NUWORD, ATS, NOATS)                              2510
           E'L
                 WHENEVER I .GE. 0                                             2550
           IAT=I
                       WHENEVER .NOT. THEN                                     2560
                             BITS(I,0)=OR.(BIT(0),BITS(I,0))                   2570
                             BITS(I,1)=OR.(BIT(1),BITS(I,1))                   2580
                       OTHERWISE                                               2590
                             BITS(I,2)=OR.(BIT(0),BITS(I,2))                   2600
                             BITS(I,3)=OR.(BIT(1),BITS(I,3))                   2610
                       END OF CONDITIONAL                                      2620
                             BIT(0) = 0                                        2630
                             BIT(1) = 0                                        2640
                 OTHERWISE                                                     2650
ATTERR     CONTINUE
                       NOATT = NUWORD                                        2660
           P'T FOMAT,NOATT...NOATT(4)
          R(**SKIP TO NEXT ELEMENT DESCRIPTION.)
           SK=2
           EXECUTE SKPDES.
           TRANSFER TO FINISH
                 END OF CONDITIONAL                                          2680
           END OF CONDITIONAL
           END OF CONDITIONAL                                                2690
           VECTOR VALUES NOATT= $ $,$ NOT ON ATTACHMENT LISTS$               2700
           TRANSFER TO RESET2                                                2710
          R                                                                  2720
          R                    CAPABILITY STATEMENT DECOMPOSITION            2730
          R                                                                  2740
          R                    PERIOD,CAPABILITY FINISHED.                   2750
 PART(1)   CONTINUE
           TRAP = 0B
           CPABLE = 1B                                                       2760
           PERIOD = 1B
           DWORD=$ $
           T'O READ2
```

```
          R                    LEFT PAREN                                  2810
 PART(2)   CONTINUE
           W'R TRAP.AND.TRAP1
           PAREN = 1B
           T'O PART(0)
           CTHERWISE
           TRAP = 0B
           PAREN = 1B
           WHENEVER WITH. TRANSFER TO RESET2
           TRANSFER TO PARNAM                                             2840
           E'L
          R                    RIGHT PAREN                                 2850
PART(3)    CONTINUE                                                       2860
           WHENEVER .NOT. PAREN                                           2880
           PRINT COMMENT $0ERRORS$
           TRANSFER TO NUSTA2
           CTHERWISE                                                      2910
           PAREN = 0B
           WHENEVER WITH.TRANSFER TO WITHOT
             TRANSFER TO ATTNAM                                           2920
           END OF CONDITIONAL                                             2930
          R                    EQUAL SIGN NOT OBSERVED HERE.               2940
          R                    COMPUTE                                     2950
  PART(5)  CONTINUE
           TRAP = 0B
           BIT(1)=INBIT.(BIT(1).34.1)
           THEN=1B
           TRANSFER TO RESET2
          R                    ESTIMATE                                    2980
  PART(4)  CONTINUE
           TRAP = 0B
           THEN = 1B
           W'R CH(SI) .E.$.$
           CPABLE = 1B
           PERIOD = 1B
           E'L
           TRANSFER TO RESET2                                             3010
          R                    WITHOUT                                     3020
  PART(6)  CONTINUE
           WITH = 1B
           W'R CH(SI) .E. $($. SI=SI-1
           TRANSFER TO RESET2
WITHOT     CONTINUE
           WITH=0B
           W'R TRAP
           J = LOCATE.(DWORD(0).ATS.NOATS)
           TRAP = 0B
           OTHERWISE
           J = LOCATE.(NUWORD.ATS.NOATS)
           E'L
           WHENEVER J.GE. 0
           BITS(J.3)=INBIT.(BITS(J.3).35.1)
           NUWORD = $ $                                                   3060
           DCNT = 0                                                       3070
           OTHERWISE
           TRANSFER TO ATTERR
           END OF CONDITIONAL
           TRANSFER TO RESET2                                             3080
          R                                                               3090
```

```
          R                                                              3100
                              ENTRY TO ENDDES.
           NOATS = ARG2
           W'R CKRN
           PRINT COMMENT $0ENDDES$
           E'L
FINISH     CONTINUE
           W'R CKRN
           PRINT COMMENT $0FINISH$
           E'L
           THEN = 0B
           WHENEVER NOATS.LE. 1, NOATS=1
           K = (NOATS  )*4-1
           WHENEVER .NOT. ALLSET
           ALLSET = 1B
           WRITE BINARY TAPE T4, ELNAME, NOATS
           WRITE BINARY TAPE T4,ATS(0)...ATS(NOATS-1)
           SCCNT=0
           SCOPB1 = SBIT(0)
           SCOPB2 = SBIT(1)
           P'T FOMAT,ELNAME
           P'T BITP,$SCOPBT$,SCOPB1,SCOPB2
           END OF CONDITIONAL
           WRITE BINARY TAPE T4, BITS(0)...BITS(K)
           T'H BITPR, FOR I=0,1,I.G.NOATS -1
           PRINT FORMAT BITP, ATS   (I),BITS(I,0)...BITS(I,3)
           V'S BITP = $1H C6,4(S2,K12)*$
 BITPR     CONTINUE
          R                                                              3180
           SCCNT = SCCNT +1                                              3220
           MAD(SCCNT ) = MADCNT                                          3190
           MADCNT = 0                                                    3200
           EXECUTE PLACE.(BITS,K+1,0)
          R                    NEXT STATEMENT COLLECTION SETUP          3230
           TRANSFER TO TYPE(SK)                                          3240
TYPE(0)    BIT(0) = 0                                                    3250
           BIT(1) = 0                                                    3260
           CPABLE = 0B                                                   3270
           PERIOD = 0B
           DWORD(1) = $ $
           DWORD(0) = $ $
           TRAP = 0B
           TRANSFER TO READ2
          R                    DESCRIPTION FINISHED OR ANOTHER FOLLOWS.  3290
TYPE(1)    CONTINUE                                                      3300
 TYPE(2)   CONTINUE
           END OF FILE TAPE SCRAP
           REWIND TAPE SCRAP                                             3360
           PRINT COMMENT $ORCNO   COLNO$
           ALLSET = 0B
           END OF FILE TAPE T4                                           3340
           NELNAM = NOT.(ELNAME)
           WRITE BINARY TAPE T4,NELNAM
           EXECUTE SETEOF.(ERRT3)
           THROUGH CARDMA, FOR I = 1,1, I .G. SCCNT                      3370
           WRITE BINARY TAPE T4, MAD(I), I                               3380
           P'T $216*$,MAD(I),I
           THROUGH CARDMA, FOR J=1,1, J.G. MAD(I)                        3390
           READ BINARY TAPE SCRAP, WORD(0)...WORD(11)                    3400
```

```
          W'R CKRN
          P'T FOMAT,WORD...WORD(11)
          E'L
CARDMA    WRITE BINARY TAPE T4, WORD(0) ... WORD (11)                    3410
FILE      END OF FILE TAPE T4
          REWIND TAPE SCRAP                                              3430
          PRINT COMMENT $6$
          NOATS=0
          SCCNT = 0                                                      3440
          I=SI
          WHENEVER EOFB, FUNCTION RETURN 1
          FUNCTION RETURN 2
          DIMENSION DWORD(4)
         R      RESETS FOR ELEMENT DESCRIPTION RETURNS                   4200
         R                                                              4210
NUCAR2    SI=71
NUSTA2    DCNT=0
RESET2    HOLCNT = 1                                                     4240
          NUWORD = $ $                                                   4250
STMNT     CONTINUE                                                       3890
          W'R CPABLE, T'O MADOUT
          WHENEVER .NOT. PERIOD.AND..NOT.CPABLE, TRANSFER TO PART(1)
          TRANSFER TO READ2                                              3900
ERRT3     CONTINUE
          PRINT COMMENT $0END OF FILE ON SCRATCH TAPE - IMPROPERLY FOUN
         1D IN FINISHING ELEMENT DESCRIPTION.$
          IFERR1= 1B                                                     3457
          EXECUTE SETEOF.(0)
          TRANSFER TO FILE
MADOUT    WRITE BINARY TAPE SCRAP, WORD(0) ... WORD (11)                 3460
          W'R MADCNT .E. 0
          P'T $T106,H*STATEMENT COLLECTION *I3*$,SCCNT+1
          E'L
          TRAP1 = 0B
          MADCNT = MADCNT+1                                              3480
          TRANSFER TO READ2                                              3490
         R                                                              2210
         R                                                              2220
          INTERNAL FUNCTION
          EQUIVALENCE(EOF2,EOFL2)
          ENTRY TO SKPDES.
          W'R CKRN
          PRINT COMMENT $0SKPDES$
          E'L
          I=0
READ3     EXECUTE INPUT.(CH...EOF2,WORD)
          I= I+1
          WHENEVER CH.E.$/$,TRANSFER TO READ3
          THROUGH ST1, FOR SI=0,1,SI.GE. 72
          NUCHAR= CH(SI)
          WHENEVER NUCHAR.E. $ $,TRANSFER TO ST1
PUNCT3    THROUGH PUNCT3, FOR K=0,1,K.G. 4.OR.PUNCT(K).E. NUCHAR
          W'R NUCHAR .E. $'$
          ABRSW=1B
          C'R ABRSW
          ABRSW=0B
          HOLCNT=6
          E'L
          WHENEVER K.LE.4.OR.HOLCNT.G.6
```

```
          THROUGH TYPECK, FOR VALUES OF K=1,2,7
               WHENEVER STYPE1(K).E. NUWORD , TRANSFER TO RETRN
          W'R ABR(K) .E. NUWORD, T'O RETRN
TYPECK    CONTINUE
               TRANSFER TO RESET3
          END OF CONDITIONAL
           NUWORD= INSRTC.(NUWORD, HOLCNT,NUCHAR)
          HOLCNT = HOLCNT+1
ST1       CONTINUE
RESET3    NUWORD= $ $
          HOLCNT = 1
          TRANSFER TO READ3
EOFL2     EOFB= 1B
RETRN     P'T SKIPPD,I
          V'S SKIPPD=$I5,H* CARDS SKIPPED IN THIS ELEMENT DESCRIPTION**
         1$
          SI=0
          IFERR2=1B
          FUNCTION RETURN
          END OF FUNCTION
         R
          PROGRAM COMMON A,CH
          V'S FOMAT=$1H 21C6*$
          NORMAL MODE IS INTEGER                                          70
          DIMENSION B(12)
          DIMENSION END1(12)
           DIMENSION WORD(11),
         1S(42,DIMS),  DWORD(4), PNUM(1), AMB(7),CH(71)
          DIMENSION BIT(1),EQER(9),PART1(7),PART2(7),PART(7)
         1            ,S2(8),TYPE(7)
         2            ,BITS(80,DIM3),MAD(50)
          DIMENSION SBIT(1),SCOPB1(1),ATS(20),EQUER(9)
          DIMENSION PELT(300),ELN(95),FPAR(71),ZPAR(69)
          DIMENSION A(15999,DIM1),PCNT(1)
          VECTOR VALUES THREE= 3
          VECTOR VALUES FOUR = 4
          VECTOR VALUES DIMS = 2,7,6
          VECTOR VALUES DIM1 = 2,401,400                                  030
          VECTOR VALUES DIM3=2,5,4
          VECTOR VALUES A(15600)=$ELTAPE$
          EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),
         1            ( A(15603),PARCNT ),( A(15604),ELN    ),
         2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),
         3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),
         4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),
         5            ( A(15843),SCNT   ),( A(15844),ECNT   ),
         6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),
         7            ( A(15848),ID1    ),( A(15849),ID2    ),
         8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )
         9           ,( A(15853),DIM1),(A(15889),FIVE)
          EQUIVALENCE (PELT,A(8200))
          EQUIVALENCE (A(15890),NUCHAR)
          EQUIVALENCE (A(15891),ELNAME)
          DIMENSION ELNAME(1)
          DIMENSION VCK(10)
          EQUIVALENCE (A(15900),VCK)
          EQUIVALENCE ( A(15856),CKRN   ),( A(15857),THREE  )          E    1
         1,            (A(15858),FOUR   ),(A(15859),CLDONE)
          EQUIVALENCE(A(15870),B),(A(15860),NUWORD),(A(15861),SBIT)
```

```
 EQUIVALENCE(A(8000),BITS),(A(8080),ATS),(A(8100),MAD)
1           ,(ELTPOK,TAPEOK),(ATTCNT,NOATS)
2           ,(T4,FOUR),(SCRAP, FIVE)
 BOOLEAN CLDONE
 BOOLEAN CAT,CEL,CTO,CEID,PLP1,                                          0110
1PLP2, PEL, PAT, IFERR1, IFERR2, TAPEOK, OUT, FEL, FSN                   0120
2 ,CLC    , NTAPE, EOFB , SET4,    CKRN                                 0130
 BOOLEAN EPAR, EEL, EEID, EAT, E2NDPN                                    0140
 BOOLEAN SPAR, SEL, SEID, SAT, S2NDPN, S1STEQ                            0160
 BOOLEAN FSNEW,FSOLD, FSEL                                               0190
 BOOLEAN CPABLE,DONE,EQUAL,ELTPOK,PAREN,THEN
 BOOLEAN NUELTP                                                    B      4
 BOOLEAN ALLSET, PERIOD
 BOOLEAN WITH
R
R                    ** COMPILOR CONTROL CARDS **
R
 VECTOR VALUES PUNCT=$,$ , $.$ , $($ , $)$ , $=$
 END OF FUNCTION                                                         *
```

```
$COMPILE MAD,PRINT OBJECT, PUNCH OBJECT                                PARCK000
          EXTERNAL FUNCTION(Q)
          R'N
          DEFINE UNARY OPERATOR .BLANK. , PRECEDENCE SAME AS .ABS.
          MODE STRUCTURE 1 = .BLANK. 1
      CLA     B
      ARS     18
      ALS     18
      OUT     AC
      END
          ENTRY TO PARCK.                                                  3540
          I= Q
          W'R CKRN
          PRINT COMMENT $OPARCKS
          E'L
         R                                                                 3550
         R                    IF PAR NOT ON LIST PUT IT ON AND  GENERATE   3560
         R                    A UNIQUE NAME ON ZPAR LIST                  3570
          PI = LOCATE.( NUWORD, FPAR, PARCNT)                             3580
          WHENEVER PI .L. 0                                               3590
                FPAR(PARCNT) = NUWORD                                     3600
                PI = PARCNT                                               3610
          NUWORD= .BLANK. (NUWORD)
         R             CHECK UNIQUENESS OF NUWORD ON ZPAR LIST.           3630
                K= 3                                                      3640
                I = 0                                                     3650
ZLIST           J = LOCATE.(NUWORD, ZPAR, PARCNT)                         3660
          WHENEVER J .GE. 0                                               3670
          WHENEVER I .L. 26                                               3680
                I = I+1                                                   3690
          NUWORD = INSRTC.(NUWORD,K,NUM(I))
          OTHERWISE                                                       3710
                I=10
                K = 2                                                     3730
          END OF CONDITIONAL                                              3740
          TRANSFER TO ZLIST                                               3750
          OTHERWISE                                                       3760
                ZPAR(PARCNT) = NUWORD                                     3770
                PARCNT = PARCNT+1                                         3780
          W'R PARCNT .G. 70, PRINT COMMENT $OPARAMETER TABLE LENGTH EXC
         1EEDED.$
          END OF CONDITIONAL                                              3810
          OTHERWISE                                                       3811
               J=PI/36                                                    3812
               I= PI-J*36                                                 3813
               ASSERT = NUWORD                                            3814
                WHENEVER IFBIT.(SCOPB1(J),I).AND..NOT.IFBIT.(SBIT(J),I)
               SCOPB1(J)= INBIT.(SCOPB1(J),I,0)
          P'T FOMAT, ASSERT...ASSERT(7)
          END OF CONDITIONAL
          END OF CONDITIONAL                                              3820
          FUNCTION RETURN (PI)                                            3830
          VECTOR VALUES NUM= $1$, $2$,$3$,$4$,$5$,$6$,$7$,$8$,$9$,$A$,$  3860
         1B$,$C$,$D$,$E$,$F$,$G$,$H$,$I$,$J$,$K$,$L$,$M$,$N$,$O$,$P$,$Q  3870
         1$,$R$,$S$,$T$,$U$,$V$,$W$,$X$,$Y$,$Z$                           3880
          VECTOR VALUES ASSERT=$ $,$ IS NOT BROAD SCOPE IN THIS ELEMENT
         1 DESCRIPTION.$
         R                                                                3850
          PROGRAM COMMON A
```

```
          V'S FOMAT=$1H0,22C6*$
          DIMENSION A(15999),SBIT(1),SCOPB1(1), FPAR(71),ZPAR(69)      D      1
          NORMAL MODE IS INTEGER
          EQUIVALENCE(A(15700),FPAR)  ,(FPAR(70),SCOPB1)               E      1
         1      ,(A(15603),PARCNT),(A(15861),SBIT)
         2      ,(A(15860),NUWORD),(A(15772),ZPAR)
         3       ,(A(15856),CKRN)
          BOOLEAN IFABIT,, IFBIT
          BOOLEAN CKRN
          END OF FUNCTION                                                 *
$ASSEMBLE,PUNCH OBJECT                                                PLACE000
       ENTRY PLACE       CALLING SEQUENCE EXECUTE PLACE,(A(N),L,$B$)
PLACE  NOP
 IN    CLA      1,4
       ADD      IN
       STA      BASE
       CLA*     2,4
       PAX      0,1
       CAL*     3,4            SIX CHARACTER WORD TO BE STORED IN
BASE   SLW      **,1     A(N),...,A(L)
       TIX      BASE,1,1
       TRA      4,4
       END                                                              *
```

```
$ASSEMBLE,PUNCH OBJECT                                          RDTP4 00
        ENTRY   RDTP4
RDTP4   CAL*    1,4
        ALS     18
        STD     UNIT
        STD     UNITA
        STD     UNITB
        CAL     2,4
        STA     SCRTCH
        CAL     3,4
        STA     WORD1
        CAL     4,4
        STA     WORD2
        SXA     RET,4
        CALL    RDSBIN
UNIT    BLK     RET,,**
        BLK     WORD1
        BLK     EOF,,RTT
        CALL    CHEKIO
UNITA   BLK     ,,**
        CALLIO  .PRINT
        FMT     FORMAT
        ENDIC
        CALL    SYSTEM
FORMAT  BCI     *,H*0HELP - IO TRAP DOESNT UNDERSTAND ME.**
WORD1   IOBP    **,,1
WORD2   IOBT    **,,1
EOF     CALLIO  .PRINT
        FMT     EOFMSG
        ENDIC
SCRTCH  TRA     **
EOFMSG  BCI     *,H*0EOF DETECTED ON FOUR - ASSUME IT IS SCRATCH.**
RTT     CALL    RDSDEC
UNITB   BLK     ,,**
        BLK     WORD1
        BLK     0,0,0
        CALLIO  .PRINT
        FMT     REDMSG
        ENDIC
        TRA     SCRTCH
REDMSG  BCI     *,H*0TAPE FOUR REDUNDANCY - ASSUME SCRATCH.**
RET     AXT     **,4
        TRA     5,4
        END                                                     *
$COMPILE MAD,PRINT OBJECT,PUNCH OBJECT                          ST END00
            EXTERNAL FUNCTION(ZZ)
            R'N
            V'S NONS=$PADPADPADPADPADPAD$
            ENTRY TO START.
            DONE = 0B
            OUT = 0B
            IFERR2=0B
STCC(0)     REWIND TAPE FOUR
            REWIND TAPE THREE
            REWIND TAPE FIVE
            EXECUTE RDTP4.(FOUR,HA,ELTCK,IDENT)
            W'R (ELTCK .NE. $ELTAPE$) .OR. (ZZ .NE. IDENT)
HA          REWIND TAPE FOUR
            WRITE BINARY TAPE FOUR,$ELTAPE$,ZZ,NONS...NONS(2)
```

```
          WRITE BINARY TAPE FOUR,PELCNT,TELCNT,PARCNT,NONS...NONS(2)
          WRITE BINARY TAPE FOUR,A(15604)...A(15853)
          END OF FILE TAPE FOUR
          PRINT COMMENT $0ELTAPE FILE 1 WRITTEN.$
          WRITE BINARY TAPE FOUR,$PROLOG$,NONS...NONS(2)
          C'E
          TAPEOK=1B
          READ BINARY TAPE FOUR,PELCNT,TELCNT,PARCNT
          READ BINARY TAPE FOUR,A(15604)...A(15853)
          E'L
          TELCNT = 0
          FUNCTION RETURN
          ENTRY TO END.
          X= ZZ
          WHENEVER .NOT. (X.GE. 3 .OR. X .L. 0), TRANSFER TO PART(X)
          PRINT COMMENT $0X DOES NOT EQUAL 0,1,2, ERROR IN END.$
PART(0)   CONTINUE
          SW=0
          WHENEVER .NOT.DONE,TRANSFER TO END1
          PRINT COMMENT $2NORMAL TERMINATION - DATA EXHAUSTED$
         R   MUST SAVE ELEMENT TAPE IF OURS USED                          1330
          EXECUTE SYSTEM.                                                 1350
PART(1)   CONTINUE
          SW=1
          OUT= 1B
END1      CONTINUE
          EXECUTE CONCK.                                                  1370
          WHENEVER IFERR2                                                 1380
          PRINT COMMENT $0AMBIGUOUS DATA, PROBLEM CANNOT CONTINUE$
          OR WHENEVER IFERR1                                              1410
          PRINT COMMENT $0MINOR ERROR, PROGRAM CONTINUING$
          END OF CONDITIONAL                                              1440
          EXECUTE SYNONM.(SCNT)
         R   ELIMINATE SYNONYMS
          EXECUTE SYNELM.
         R   PRINT OUT CONNECTIONS LIST
          EXECUTE CONNEC.(CCNT)
          WHENEVER PCNT .G. PCNT(1)
               COUNT = PCNT
          OTHERWISE
               COUNT = PCNT(1)
          END OF CONDITIONAL
          EXECUTE INPTPR.(COUNT)
          WHENEVER FSCNT .G. ECNT
               COUNT = FSCNT
         R   PRINT OUT EQUIVALENCE LISTS
          OTHERWISE
               COUNT = ECNT
          END OF CONDITIONAL
          DONE=1B
          FUNCTION RETURN
PART(2)   CONTINUE
          EXECUTE EQUIVN.(COUNT)
          EXECUTE IPRELM.
          PRINT COMMENT $0FPAR$
          P'T FOMAT,FPAR...FPAR(PARCNT-1)
          PRINT COMMENT $0ZPAR$
          P'T FOMAT,ZPAR...ZPAR(PARCNT-1)
          EXECUTE SEQPGM.
```

```
          INTERNAL FUNCTION (KOUNT)
          FORMAT VARIABLE FV1,FV2
          ENTRY TO SYNONM.
          PRINT COMMENT $1SYNONYMS.$
          LOW=21
          HIGH=30
          FV1=1
          FV2=5
LIST      P'T FORM,TITLE...TITLE(6),TITLE(2),...,TITLE(6)
          V'S FORM=$1H0,12(C6,S4)*$
          V'S TITLE=$COUNT$,$TRUNAM$,$PARAM$,$ELEM$,$EID$,$ATT$,$AID$
          T'H LIST1, FOR K=0,1, K .G. KOUNT-1
LIST1     P'T FORM1,K,(J=LOW,1, J .G. HIGH, A(J,K))
          V'S FORM1=$1H0,I3,S7,2('FV1'S10,'FV2'(C6,S4),S-10),T122*$
          F'N
          ENTRY TO CONNEC.
          PRINT COMMENT $-CONNECTIONS.$
          LOW=31
          HIGH=38
          FV1=2
          FV2=4
          T'O LIST
          ENTRY TO INPTPR.
          PRINT COMMENT $-INPUT PARAMETERS AND DESIRED RESULTS.$
          LOW=4
          HIGH=13
          FV1=1
          FV2=5
          T'O LIST
          ENTRY TO EQUIVN.
          PRINT COMMENT $-EQUIVALENCES.$
          LOW=14
          HIGH=19
          FV1=0
          FV2=6
          T'O LIST
          E'N
          PROGRAM COMMON A
          NORMAL MODE IS INTEGER                                          70
          DIMENSION FPAR(71),ZPAR(69)
          DIMENSION A(15999,DIM1),PCNT(1)
          VECTOR VALUES TWO = 2                                       V    5
          VECTOR VALUES THREE= 3
          VECTOR VALUES FOUR = 4
          VECTOR VALUES FIVE =9
          VECTOR VALUES DIM1 = 2,401,400                                  30
          V'S FOMAT=$10(S6,C6)*$
          VECTOR VALUES A(15600)=$ELTAPE$
          EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),
         1            ( A(15603),PARCNT ),( A(15604),ELN    ),
         2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),
         3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),
         4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),
         5            ( A(15843),SCNT   ),( A(15844),ECNT   ),
         6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),
         7            ( A(15848),ID1    ),( A(15849),ID2    ),
         8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )
         9           ,( A(15853),DIM1)
          EQUIVALENCE (A(15889),FIVE)
```

```
 EQUIVALENCE ( A(15856),CKRN   ),( A(15857),THREE  )          E       1
1           ,( A(15858), FOUR  ),( A(15859),CLDONE  )
 EQUIVALENCE(A(8000),BITS),(A(8080),ATS),(A(8100),MAD)
1          ,(ELTPOK,TAPEOK),(ATTCNT,NOATS)
 BOOLEAN CLDONE
 BOOLEAN CPABLE,DONE,EQUAL,ELTPOK,PAREN,THEN
 BOOLEAN CAT,CEL,CTO,CEID,PLP1,                                          0110
1PLP2, PEL, PAT, IFERR1, IFERR2, TAPEOK, OUT, FEL, FSN                   0120
2 ,CLC    , NTAPE, EOFB , SET4,   CKRN                                  0130
 BOOLEAN EPAR, EEL, EEID, EAT, E2NDPN                                    0140
 BOOLEAN SPAR, SEL, SEID, SAT, S2NDPN, S1STEQ                            0160
 BOOLEAN FSNEW,FSOLD, FSEL                                               0190
 BOOLEAN NUELTP                                                      B       4
 EQUIVALENCE (SCRAP,FIVE),(T4,FOUR)
 END OF FUNCTION                                                             *
```

```
$COMPILE MAD,PRINT OBJECT,PUNCH OBJECT                                  SYNELM00
          EXTERNAL FUNCTION
          R'N
         R SYNONYM ELIMINATION                                                  10
          ENTRY TO SYNELM.                                                    0400
         R      -BRIEF DESCRIPTION OF FOLLOWING PROGRAM-                      0020
         R THE I-TH ROW OF THE SYNONYM TABLE IS COMPARED BY SEARCHS TO        0030
         R 1. FUNCTION SUBSTITUTION LIST   - SEARCH  1                        0040
         R 2. (A)INPUT PARAMETERS LIST       SEARCH  2                        0050
         R    (B)DESIRED RESULTS LIST                                         0060
         R    (C)EQUIVALENCE LIST                                              70
         R 3.CONNECTIONS LIST.                -SEARCH  3                      0080
         R WHEN A MATCH IS FOUND IN THE ABOVE LISTS, THE TRUE MAMES           0090
         R      REPLACE THE SYNONYMOUS NAMES IN THE LIST.                     0100
         R                                                                    110
          THROUGH LOOPA,FOR I=0,1,I.GE. SCNT
          OCCURS  = 0B                                                       1170
          TPAR = A(21,I)                                                     0490
          TEL  = A(22,I)                                                     0500
          TEID = A(23,I)                                                     0510
          TAT  = A(24,I)                                                     0520
          TAID = A(25,I)                                                     0530
          SYPAR= A(26,I)                                                     0540
          SYEL = A(27,I)                                                     0550
          SYEID= A(28,I)                                                     0560
          SYATT= A(29,I)                                                     0570
          SYAID= A(30,I)                                                     0580
          EXECUTE SRCH1.                                                     0600
          COUNT = PCNT(0)                                                    0610
          EXECUTE SRCH2.(A(4,0),A(5,0),A(6,0),A(7,0),A(8,0))                 0630
          COUNT = PCNT(1)                                                    0640
          EXECUTE SRCH2.(A(9,0),A(10,0), A(11,0),  A(12,0) ,A(13,0))         0660
          COUNT = ECNT                                                       0670
          EXECUTE SRCH2.(A(14,0), A(15,0),A(16,0) ,A(17,0) ,A(18,0))         0690
          EXECUTE SRCH3.                                                     0710
          W'R .NOT. OCCURS, P'T FOMAT, NO...NO(9)
LOOPA     CONTINUE                                                           0720
          FUNCTION  RETURN                                                   0730
          INTERNALFUNCTION(AA,AB,AC,AD,AE)                                   0740
         R SEARCH OF     INPUT PARAMETER,DESIRED RESULTS,EQUILIALENCE        0750
          ENTRY  TO SRCH2.                                                   0760
          THROUGH  LOOPS, FOR L=0,1,L.GE.COUNT
          WHENEVER  (SYAID.E.AE(L).OR.   SYAID.E.$ $ )                       0780
         1.AND.(SYATT.E.AD(L)    .OR. SYATT .E. $ $    )                    0790
         2.AND.(SYEID.E.AC(L)    .OR. SYEID .E. $ $    )                    0800
         3.AND.(SYEL.E.AB(L)    .OR. SYEL  .E. $ $  )                       0810
         4.AND.(SYPAR.E.AA(L)    .OR. SYPAR .E. $ $    )                    0820
          WHENEVER TPAR .NE. $ $, AA(L) = TPAR                               0830
          WHENEVER TEL  .NE. $ $, AB(L) = TEL                                0840
          WHENEVER TEID .NE. $ $, AC(L) = TEID                               0850
          WHENEVER TAT  .NE. $ $, AD(L) = TAT                                0860
          WHENEVER TAID .NE. $ $, AE(L) = TAID                               0870
                              OCCURS = 1B                                    0910
LOOPS     END OF CONDITIONAL                                                 0920
          FUNCTION RETURN                                                    0930
          END OF FUNCTION                                                     094
         R SEARCH OF SUBSTITUTION  TABLE.                                    0950
          INTERNAL FUNCTION                                                  0960
          ENTRY TO SRCH1.                                                    0970
```

```
          WHENEVER TPAR.E.$ $,FUNCTION RETURN
          THROUGH LOOPSB, FOR L =0,1,   L .GE. FSCNT                    0980
          EQUIVALENCE (A(800),ACOL2),(A(1200),ACOL3)                    0990
          WHENEVER (SYEID .E.ACOL3(L)      .OR. SYEID .E. $ $)          1000
         1.AND.(SYEL.E.ACOL2(L)       .OR.  SYEL .E.  $ $ )             1010
          WHENEVER TEL .NE. $ $, ACOL2(L) = TEL                         1020
          WHENEVER TEID .NE. $ $, ACOL3(L) = TEID                       1030
                           OCCURS = 1B                                  1070
LOOPSB    END OF CONDITIONAL                                            1080
          BOOLEAN OCCURS                                                1100
          FUNCTION  RETURN                                              1110
          END OF FUNCTION                                               1120
         R  SEARCH OF CONNECTIONS                                       1130
          INTERNAL FUNCTION                                             1150
          ENTRY TO SRCH3.                                               1160
          WHENEVER TPAR .NE. $ $, FUNCTION RETURN
          THROUGH LOOPC, FOR L=0,1,L.GE.CCNT                            1180
          WHENEVER  (SYAID .E. A34(LCNT).OR.  SYAID .E. $ $)            1190
         1.AND.(SYATT.E. A33(LCNT)         .OR.  SYATT .E. $ $)         1200
         2.AND.(SYEID.E. A32(LCNT)         .OR.  SYEID .E. $ $)         1210
         3.AND.(SYEL .E. A31(LCNT)         .OR.  SYEL  .E. $ $)         1220
          WHENEVER TEL .NE. $ $, A31(L) = TEL                           1230
          WHENEVER TEID.NE. $ $, A32(L) = TEID                          1240
          WHENEVER TAT .NE. $ $, A33(L) = TAT                           1250
          WHENEVER TAID.NE. $ $, A34(L) = TAID                          1260
          END OF CONDITIONAL                                            1310
          WHENEVER (SYAID .E. A38(LCNT) .OR.  SYAID  .E. $ $)           1320
         1      .AND.(    SYATT .E. A37(LCNT)  .OR.  SYATT  .E. $ $ )   1330
         2      .AND.(    SYEID .E. A36(LCNT)  .OR.  SYEID  .E. $ $ )   1340
         3      .AND.(    SYEL  .E. A35(LCNT)  .OR.  SYEL   .E. $ $ )   1350
          EQUIVALENCE(LCNT,L)                                           1370
          WHENEVER TEL .NE. $ $, A35(L) = TEL                           1380
          WHENEVER TEID.NE. $ $, A36(L) = TEID                          1390
          WHENEVER TAT .NE. $ $, A37(L) = TAT                           1400
          WHENEVER TAID.NE. $ $, A38(L) = TAID                          1410
          OCCURS = 1B                                                   1460
LOOPC     END OF CONDITIONAL                                            1470
          FUNCTION RETURN                                               1520
           END OF FUNCTION                                              1530
          DIMENSION NO(10)                                              1500
          EQUIVALENCE(NO,SYPAR),(NO(1),SYEL),(NO(2),SYEID)
         1,(NO(3),SYATT),(NO(4),SYAID)
          VECTOR VALUES NO(5)=$ DOES NOT OCCUR ON ANY LIST.$
          NORMAL MODE IS INTEGER                                        0120
          DIMENSION ERR(8)                                              0130
          DIMENSION A(15999,DIM1),                    PCNT(1)           0170
          VECTOR VALUES DIM1 = 2,401,400                                0180
         R  DEFINITION OF  A(39,0)...A(39,399)                          0190
          VECTOR VALUES A(15600)=$ELTAPE$                               0200
          EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),          0210
         1            ( A(15603),PARCNT ),( A(15604),ELN    ),          0220
         2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),          0230
         3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),          0240
         4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),          0250
         5            ( A(15843),SCNT   ),( A(15844),ECNT   ),          0260
         6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),          0270
         7            ( A(15848),ID1    ),( A(15849),ID2    ),          0280
         8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )           0290
          EQUIVALENCE (PELT,A(8200))
```

```
 DIMENSION PELT(300),ELN(95),FPAR(71),ZPAR(69)                          0300
 PROGRAM COMMON A                                                       0310
 V'S FOMAT=$1HO,22C6*$
 BOOLEAN IFERR1                                                         0320
 DIMENSION A31(1),A32(2),A33(1),A34(1),A35(1),A36(1),A37(1),            0330
1A38(1),A39(1)                                                           340
 EQUIVALENCE (A(12400),A31),(A(12800),A32),(A(13200),A33),              0350
1(A(13600),A34),(A(14000),A35),(A(14400),A36),(A(14800),A37),           0360
2(A(15200),A38)                                                          370
 EQUIVALENCE (A39,A(15600))                                             0380
 DIMENSION  ACOL2(1), ACOL3(1)                                          0390
 END OF FUNCTION                                                          *
```

```
$ASSEMBLE,PUNCH OBJECT                                    TAPE1000
        ENTRY   SKFILE
        ENTRY   SKRECD
        ENTRY   BKSPCE
SKFILE  AXT     0,1
        TRA     START1
SKRECD  AXT     1,1
START1  CLA*    2,4
        TZE     3,4
        TMI     BACKS
        STA     BLK1
        CLA     TYPE,1
        STA     CALL
        CLA*    1,4
        PAX     0,1
        SXD     BLK1,1
        SXA     XRC1,4
CALL    TSX     **,4
BLK1    BLK     **,,**
XRC1    AXT     **,4
        TRA     3,4
        CALL    SKPREC
TYPE    CALL    SKPFIL
BKSPCE  AXT     1,1
        CLA*    2,4
        TZE     3,4
BACKS   PAX     0,2
        CLA     TYPE2,1
        STA     CALL2
        CLA*    1,4
        PAX     0,1
        SXD     BLK2,1
        SXA     XRC2,4
CALL2   TSX     **,4
BLK2    BLK     **,,**
        TIX     *-2,2,1
XRC2    AXT     **,4
        TRA     3,4
        CALL    BSRTAP
TYPE2   CALL    BSFTAP
        END                                                *
```

```
$COMPILE MAD,EXECUTE,DUMP,PUNCH OBJECT ,PRINT OBJECT                CORE2000
          R'N
          PRINT COMMENT $1CORE 2$
          EXECUTE OUTPUT.($PROLOG$,1)
          P'S PELCNT,TELCNT
          THREE=3
          FOUR=4
          A(15853)=2
          A(15854)=401
          A(15855)=400
          REWIND TAPE FOUR
          EXECUTE COLIN.
          EXECUTE SSORDR.
          EXECUTE SUBSPT.(A(27,0),CCNT)
          EXECUTE PROLOG.
          P'S PELCNT,TELCNT
         R   PRINT OUT AND PUNCH EQUIVALENCE CARDS**********
           EXECUTE EQVGEN.
          SQUEEZ.
          SNOW.
          EXECUTE SEQPGM.
          INTERNAL FUNCTION
              ENTRY TO PROLOG.
          EXECUTE OUTPUT.($PROLOG$,1)
          REWIND TAPE FOUR
          TAPCO = 0
 REP1     READ BINARY TAPE FOUR, IDENT
          EXECUTE OUTPUT.(IDENT,1)
          WHENEVER IDENT .E. $PROLOG$.OR. IDENT.E.$ PROLO$,TRANSFER TO
         1GO1
          EXECUTE SKFILE.(FOUR, 1)
          TAPCO = TAPCO+1
          EXECUTE OUTPUT.(TAPCO,1)
          WHENEVER TAPCO .G. 12, EXECUTE ERR.(10000)
          TRANSFER TO REP1
 GO1      CONTINUE
          SETEOF.(GO22)
          REWIND TAPE THREE
          TAPCO1 = 0
REP2      CONTINUE
 GO22
          READ BINARY TAPE THREE, IDENT
          EXECUTE OUTPUT.(IDENT,1)
          WHENEVER IDENT.E. $  CALC$,TRANSFER TO GO2
          W'R IDENT.E.$FSUB.$
          TAPCO1 = TAPCO1 +1
          W'R TAPCO1.G. 2
          PRINT COMMENT$ HELP I'M CAUGHT IN A CHINESE IBM FACTORY$
          EXECUTE ERROR.
          E'L
          REWIND TAPE THREE
          T'O REP2
          E'L
          EXECUTE SKFILE.(THREE,1)
          TAPCO = TAPCO+1
          EXECUTE OUTPUT.(TAPCO,1)
          WHENEVER TAPCO .G. 12, EXECUTE ERR.(13000)
          TRANSFER TO  REP2
GO2       CONTINUE
```

```
          UNIT = FOUR
          CKRN = 1B
          EOFBLN = 0B
          CCOUNT  = 0B
          PLSFLG =0B
          MINFLG= 0B
          MCOUNT = 0B
         R  (**CALCULATIONS ARE ON TAPE THREE, FILE ONE.)
SCANS     CONTINUE
          EXECUTE OUTPUT.($SCANS$,1)
          EXECUTE PSCAN.
          WHENEVER MINFLG
             EXECUTE CALCS.
          PLSFLG = 0B
             MINFLG = 0B
             WHENEVER MCOUNT, TRANSFER TO PRON
             MCOUNT=1B
             TRANSFER TO SCANS
          END OF CONDITIONAL
          TRANSFER TO SCANS
PRON      CONTINUE
          EXECUTE OUTPUT.($PRON $,1)
          EXECUTE PSCAN.
          WHENEVER MINFLG
          MINFLG = 0B
          EXECUTE OUTPUT.(JACK,6)
          EXECUTE OUTPUT.(JACK2,3)
          V'S JACK2 = $ PROLOG RETURNED    $
          FUNCTION RETURN
          END OF CONDITIONAL
          ERR.(2090)
           VECTOR VALUES JACK = $ LAST MINUS SIGN IN NEW ELEMENT TAPE$
          END OF FUNCTION
         R
          INTERNAL FUNCTION
              ENTRY TO CALCS.
          EXECUTE OUTPUT.($CALCS$,1)
          WHENEVER .NOT. CLDONE, FUNCTION RETURN
          UNIT = THREE
          MINFLG = 0B
          PLSFLG = 0B
          EXECUTE PSCAN.
          W'R MINFLG
          UNIT = FOUR
          FUNCTION RETURN
          O'R PLSFLG
          PRINT COMMENT $ CALCULATIONS ENDED     $
          UNIT = FOUR
          FUNCTION RETURN
          OTHERWISE
             EXECUTE OUTPUT.(CERR,5)
          VECTOR VALUES CERR=$CALCULATIONS IMPROPERLY TERMINATED.$
          END OF CONDITIONAL
          UNIT = FOUR
          FUNCTION RETURN
          END OF FUNCTION
         R     (**PROLOGUE SECTION STORAGE ASSIGNMENTS.)
          PROGRAM COMMON A,B
          PROGRAM COMMON C
```

```
          DIMENSION C(200)
          NORMAL MODE IS INTEGER
          BOOLEAN IFERR1, CKRN, FSUBIN, EPFLG, MCOUNT, BOOLN
         1,ONCEB,  ONCEBB,MINFLG,PLSFLG,SLBFLG,FINFLG
         2,CLDONE,EOFBLN,ELFLG,CCOUNT,SCANDL
          VECTOR VALUES DIM1 = 2, 401,400
          VECTOR VALUES PDIM =2,6,5
          VECTOR VALUES THREE= 3
          VECTOR VALUES FOUR = 4
          VECTOR VALUES FIVE = 9
          DIMENSION A(15999,DIM1),PELT(299,PDIM),T(300),ATTNO(50)
         1,BFR(200),FPAR(71),ZPAR(69),B(1999 ,PDIM),PCNT(1)
          EQUIVALENCE (PCNT(0),IPCNT),(PCNT(1),DRPCNT)
         2,(T(100),FPAR),(T(172),ZPAR) ,(T(259),CLDONE)
         3,(T(276),FCNO),(T(245),PCNT),(T(273),UNIT),(T(294),LOCLBL)
         4,(T(248),ID1),(T(250),IFERR1),(A(6600),BFR)
          EQUIVALENCE (T,A(15600))  ,(T(1),PELCNT)
         1,(T(  3),PNUMBR),(T(245),IPCNT ),(T(246),DRPCNT)
         2,(T(247),FSCNT  ),(T(253),DIM1  ),(T(256),ERRNO  )
         3,(T(257),THREE ),(T(258),FOUR  ),(T(263),FSUBIN)
         4,(T(264),M     ),(T(265),CCA   ),(T(266),CARDS )
         5,(T(267),MA    ),(T(268),EPFLG ),(T(269),EPCNT )
         6,(T(270),MCOUNT),(T(271),REM   ),(T(272),BOOLN )
         7,(T(274),PXSIT ),(T(275),LINE  ),(T(277),J     )
         8,(T(278),I3    ),(T(279),I2    ),(T(284),LBWORD)
         9,(T(287),MINFLG),(T(288),PLSFLG),(T(289),FIVE  )
          EQUIVALENCE (T(242),CCNT),(T(002),TELCNT),(T(004),ELN)
         1,(T(290),SLBFLG),(T(291),FINFLG)
         6,(A( 7100),ATTNO ),(A( 8200),PELT(0))
          EQUIVALENCE(SCANDL,T(296)),(ELFLG,T(297)),(CCOUNT,T(295)),
         1(EOFBLN,T(260)),(CCA,J2),(PARCNT,PNUMBR)
          END OF PROGRAM                                                *
$ASSEMBLE,PUNCH OBJECT                                          BITLGK00
        ENTRY BLANK
        ENTRY LGR
        ENTRY LGL
        ENTRY IFABIT
        ENTRY ANDBIT
        ENTRY SIGN              C=SIGN.(A,B) CAUSES C TO HAVE SIGN OF A*B
        ENTRY EXTNAM
ANDBIT  CAL*    1,4
        ANA*    2,4
        TZE     3,4
        CLA     ONE
        TRA     3,4
IFABIT  CAL*    1,4
        TZE     2,4
        CLA     ONE
        TRA     2,4
ONE     PZE     1
EXTNAM  NOP
BLANK   CLA*    1,4
        ARS     18
        ALS     18
        TRA     2,4
LGR     CAL*    1,4
        LGR     18
        SLW     TEMP
        CLA     LBLNK
```

```
        ORA     TEMP
        TRA     2,4
LGL     CAL*    1,4
        LDQ     RBLNK                                   CK
        LGL     18
        SLW     TEMP
        CLA     RBLNK
        TRA     2,4
LBLNK   BCD 1   000
RBLNK   BCD 1000
SIGN    CLA*    1,4
        LDQ*    2,4
        LLS     0
        TRA     3,4
TEMP    SYN     -1
        END                                                     *
```

```
$ASSEMBLE,PUNCH OBJECT                                          BUFFER00
        ENTRY EQUIVN                                                    30
        ENTRY CONNEC                                                    40
        ENTRY SYNONM                                                    50
        ENTRY INPTPR                                                    60
        ENTRY SUBSPT                                                    70
        ENTRY   BITPRT          CALLING SEQUENCE)))  (B(FSTCOL),NOLINES)
EQUIVN  TSX     SETUP,2         EQUIVALENCE TABLE BUFFER SETUP
        TSX     OUTPUT,4
        TXH     VECE
        TXH     TWO
        CALL    SPRINT          LABEL FOR EQUIVALENCE
        BLK     LABELE,,19
ERESET  TSX     RESET,4                                                 90
ELSIDE  TSX     ALPHA,4                                                0100
        TSX BETA,4                                                      110
        TXL     ELSIDE,2,2399                                          0120
        TSX     STOBNK,4
        TXI     *+1,2,-8000       SUBSTUTION TABLE STARTS AT A(0)
ERSIDE  TSX     ALPHA,4                                                0160
        TSX     BETA,4                                                 0170
        TXL     ERSIDE,2,-4001                                         0180
        TSX     STOBNK,4
        TSX     WRITE,4                                                0190
        TRA     ERESET                                                 0200
CONNEC  TSX     SETUP,2         CONNECTIONS TABLE BUFFER SETUP
        TSX     OUTPUT,4
        TXH     VECC
        TXH     TWO
        CALL    SPRINT          LABEL FOR CONNECTIONS
        BLK     LABELC,,19
CRESET  TSX RESET,4                                                     220
        TSX     STOBNK,4
CLSIDE  TSX BETA,4                                                      260
        TSX ALPHA,4                                                     270
        TXL     CLSIDE,2,1599 FIRST FOUR COLUMNS 4*400-1               0280
        TSX     STOBNK,4
        CAL     TO
        TSX     STOACC,4
        TSX     STOBNK,4
CRSIDE  TSX ALPHA,4                                                     330
        TSX BETA,4                                                      340
        TXL     CRSIDE,2,3199 LAST FOUR COLUMNS 8*400-1                0350
        TSX     STOBNK,4
        TSX WRITE,4                                                     360
        TRA     CRESET                                                 0370
TO      BCD 1 TO                                                        380
SYNONM  TSX     SETUP,2         SYNONYMS TABLE    BUFFER SETUP
        TSX     OUTPUT,4
        TXH     VECS
        TXH     TWO
        CAL     EQUAL
        TRA     PNT
INPTPR  TSX     SETUP,2         INPUT PARAMETERS AND DESIRED RESULTS
        TSX     OUTPUT,4
        TXH     VECI
        TXH     TWO
        CAL     BLANK
PNT     SLW     PUNCT
```

```
        CALL    SPRINT          LABEL FOR SYNONYMS AND INPUT PARAMETER LIST
        BLK     LABELS,,19
SRESET  TSX RESET,4                                                      450
SLSIDE  TSX     ALPHA,4                                                 -470
        TSX BETA,4                                                       480
        TXL     SLSIDE,2,1599
        TSX     ALPHA,4
        CAL     PUNCT
        TSX     STOACC,4                                                 510
SRSIDE  TSX BETA,4                                                       520
        TSX     ALPHA,4                                                 0530
        TXL     SRSIDE,2,3599
        TSX     BETA,4
        TSX     STOBNK,4
        TSX     WRITE,4                                                 0550
        TRA     SRESET                                                  0560
EQUAL   BCD 1    =                                                      0570
PUNCT   BCD 1                                                            580
SUBSPT  TSX     SETUP,2         SUBSCRIPT BITS-INPUT PARAM.BITS-DES. RESULT
        STA  BASE4
        STA     BASE3                                                    610
        TSX     OUTPUT,4
        TXH     VECST
        TXH     TWO
        CALL    SPRINT          LABEL FOR SUBSCRIPT BITS
        BLK     LABBIT,,19
TRESET  TSX     RESET,4                                                  630
        SLW PARAMA
BASE4   CLA     **,2    GET NEXT NUMBER OFF THE LIST.
        STO    PARAMA
        TSX     OCTDEC,4      CONVERT TO DECIMAL INTEGER
        BLK     PARAMA
        STO     BUFER,1
        TXI     *+1,2,400
        TXI     *+1,1,1
        TXL     BASE4,2,1599
        TXI     *+1,2,-3200
        TSX     STOBNK,4
        TXL     *-1,1,10
        TSX     STOBIT,4                                                0820
        TSX     STOBIT,4        0                                       0830
        TSX     STOBNK,4
        TSX     STOBIT,4                                                0860
        TSX     STOBIT,4                                                0870
        TSX     WRITE,4                                                 0880
        TRA     TRESET                                                  0890
PARAMA  BSS 1
LOCA    BSS 1                                                           0910
ONE     PZE     1
LOCB    BSS 1                                                            930
SETUP   CLA*    2,4
        STA     COUNT
        CLA     COUNT
        TZE     3,4             NO LINES IN THE TABLE TO BE PRINTED
        STZ     ROWCNT                                                  1000
        SUB     F400
************************** TPL   *+3 CHANGED TO  TMI  *+3 **********************
        TMI     *+3
        CALL    ERR
```

```
        PAR   F400
        CLA     1,4                                                    0970
        STA     ALPHA                                                  0980
        STA     BASE                                                   0990
        SXA     IRC,4                                                  1010
        TRA     1,2
RESET   SXA     RIRC,4          RESETS THE INDEX REGISTERS  INSERTS    1040
        LXA     ROWCNT,2        CARRIAGE CONTROL                       1050
        LXA     ONE,1                                                  1060
        TSX     OCTDEC,4                                               1070
        TXH     ROWCNT                                                 1080
        ORA     CARCON                                                 1090
        TSX     STOACC,4                                               1100
        TSX     STOBNK,4
        LXA     RIRC,4                                                 1130
        TRA     1,4                                                    1140
ALPHA   CAL     **,2            TAKES THE NEXT WORD OFF THE LIST       1150
ALPHA1  SLW     BUFER,1          AND STORES THE WORD IN THE NEXT       1160
        TXI     *+1,2,400       AVAILABLE LOCATION IN THE BUFFER       1170
        TXI     *+1,1,1                                                1180
        TRA     1,4                                                    1190
BETA    LDQ     BLANK           TAKES THE NEXT WORD OFF THE LIST       1200
BASE    CAL     **,2            AND STORES THE WORD IN THE MIDDLE
        LGR     18              OF THE NEXT TWO AVAILABLE WORDS        1220
        ORA HFBLNK              IN THE BUFFER                          1230
        SLW     BUFER,1                                                1240
        TXI     *+1,1,1                                                1250
        STQ     BUFER,1                                                1260
        TXI     *+1,2,400                                              1270
        TXI     *+1,1,1                                                1280
        TRA     1,4                                                    1290
STOBNK  CAL     BLANK           STORES A BLANK IN BUFFER
STOACC  SLW     BUFER,1         STORES THE CONTENTS OF ADC IN BUFFER   1300
        TXI     *+1,1,1                                                1310
        TRA     1,4                                                    1320
WRITE   SXA     WIRC,4          PRINTS OUT NINTEEN COLUMNS OF THE BUFFER 1330
        TSX     OUTPUT,4        TRANSFER BACK TO CALLING PART IF MORE ROWS.
        TXH     BUFER-1
        TXH     NINET           BACK TO CALLIN PROGRAM IF PRINTING IS FINIS
        CLA     ROWCNT                                                 1370
        ADD     ONE                                                    1380
        STO ROWCNT                                                     1390
        SUB     COUNT                                                  1400
        LXA     WIRC,4
        TMI     1,4             TO SUBROUTINE -MORE ROWS TO BE PRINTED 1420
        LXA     IRC,4                                                  1430
        TRA     3,4             TO CALLING PROGRAM-FINISHED PRINTING   1440
WIRC    BSS 1                                                          1450
CARCON  BCD 10  000                                                    1460
IRC     BSS 1                                                          1470
HFBLNK  BCD 1   000                                                    1490
BLANK   BCD 1                                                          1500
STOBIT  SXA SIRC,4          STORE BITS OF SUBSCRIPT LISTS
BASE3   CAL **,2
        SLW PARAMB
        TSX OCT,4             CONVERT BITS INTO OCTAL EQUIVALENT
        TXH PARAMB
        TXH LOCBUF
        CAL LOCBUF
```

```
        TNZ     OUT1            IF NO BITS ARE PRESENT, REPLACE THE ZEROS
        CAL     PRD              WITH PERIODS.
OUT1    TSX     STOACC,4
        CAL     LOCBUF-1
        TNZ     OUT2
        CAL     PRD
OUT2    TSX     STOACC,4
        TXI  *+1,2,400
SIRC    AXT  **,4
        TRA  1,4
BITPRT  TSX     SETUP,2          PRINT FOR BITS IN B-REGION OF CORE 3
        STA     BASE3
        CLA     BLANK
        AXT     0,1
        STO     BUFER,1
        TXI     *+1,1,1
        TXL     *-2,1,19
        TSX     OUTPUT,4
        PAR     BITLBL
        PAR     =9
BRESET  TSX     RESET,4
        TSX     STOBNK,4
        TXL     *-1,1,3
        TSX     STOBIT,4
        TXI     *+1,2,-399
        TSX     STOBIT,4
        TXI     *+1,2,-399
        TSX     STOBNK,4
        TSX     STOBIT,4
        TXI     *+1,2,-399
        TSX     STOBIT,4
        TXI     *+1,2,-399
        TSX     WRITE,4
        TRA     BRESET
        BCD 1000000
        BCD 1E00000
        BCD 1T ABOV
        BCD 1ELEMEN
        BCD 1S FOR
        BCD 1ON BIT
        BCD 1LLECTI
        BCD 1ENT CO
BITLBL  BCD 1STATAM
PARAMB  PZE 0
LOCBUF  BES 2
        CALL    OUTPT
        CALL OUTPUT
        CALL    OCT
        CALL    OCTDEC
PRD     BCD 1 .  .
BUFER   BES 20
RIRC    BSS 1                                                    1670
ROWCNT  BSS 1
F400    PZE     400
NINET   PZE     19
TWO     PZE     2
LABELC  BCD 9                        ELEM     EID      ATT      AI
        BCD 9D                  ELEM    EID      ATT      AID
LABELE  BCD 1
```

```
        BCD 9          TRUENAME   PAR       ELEM      EID       ATT
        BCD 9    AID  SUBST.   NEW      OLD       ELEM      EID
LABELS  BCD 1
        BCD 9            PARA      ELEM     EL ID     ATT       ATT ID
        BCD 9          PARA       ELEM     EL ID     ATT       ATT ID
LABBIT  BCD 1
        BCD 9                 R      L      R-L    L-R
        BCD 9           INPUT PARAMETER BITS       DESIRED RESULT BITS
        BCD 1LENCE.                                                      CK
VECE    BCD 1EQUIVA
        BCD 1TION.                                                       CK
VECC    BCD 1CONNEC
        BCD 1PARAM
VECI    BCD 1INPUT
        BCD 1BITS.                                                       CK
VECST   BCD 1SUBST
        BCD 1MS.                                                         CK
VECS    BCD 1SYNONY
COUNT   PZE      399
N       PZE      19
        END                                                                  *
```

```
$COMPILE MAD,PRINT OBJECT,PUNCH OBJECT                                  COLIN.00
          EXTERNAL FUNCTION                                                    1230
          R'N
         R                                                                     1240
         R **      PELT=PRESENT ELEMENT TABLE   IS SET UP                     1260
         R **      ALL COLLECTIONS ARE IN CORE                                1270
         R ***** UPON COMPLETION OF THIS ROUTINE************************
          ENTRY TO COLIN.                                                      1280
          EXECUTE PLACE.(PELT,298,0)
          EXECUTE PLACE.(B,1800,0)
          PRLCNT = PELCNT + TELCNT
          J = 0
          THROUGH MOVELP, FOR I = 0,1,I.G. PRLCNT
          PELT(J) = ELN(I)
MOVELP    J = J +5
          ALLIN = 1B
                              EXECU TE OUTPUT.($COLIN.$,1)
          REWIND TAPE FOUR
                              EXECUTE OUTPUT.(LABEL , 4)
          VECTOR VALUES LABEL = $ PELCNT TELCNT PRLCNT$
                              CHECK = OCTDEC.(PELCNT)
                              CHECK(1) = OCTDEC.(TELCNT)
                              CHECK(2) = OCTDEC.(PRLCNT)
          DIMENSION CHECK(3)
          EXECUTE OUTPUT.(CHECK,3)
          M = PRLCNT
          MC=0                                                                 1310
          PELT(1)=0                                                            1320
          PELT(3)=0                                                            1330
          THROUGH LP1,FOR I=0,5,I.E.5*PRLCNT                                   1340
NXT       WHENEVER I .E. 0
          EXECUTE SKFILE.(FOUR,2)
          OTHERWISE
          EXECUTE SKFILE.(FOUR,1)
          END OF CONDITIONAL
          READ BINARY TAPE FOUR, ELN1, NOATS
          WHENEVER ELN1 .NE. PELT(I)
          MC=MC+1                                                              1390
          WHENEVER MC.G. M
          NO = ELN1
          EXECUTE OUTPUT.(NO, 8)
          VECTOR VALUES NO = $ $,$ELEMENT DESCRIPTION NOT ON TAPE FOUR$
              EXECUTE ERR.(3017)
          END OF CONDITIONAL
          TRANSFER TO NXT                                                      1410
          END OF CONDITIONAL                                                   1420
          PELT(I+2)=NOATS                                                      1430
          J=PELT(I+1)                                                          1440
          J1=J+NOATS-1                                                         1450
          PELT(I+6)=J1+1                                                       1460
          READ BINARY TAPE FOUR, ATS(J),...,ATS(J1)
          J2=4*NOATS                                                           1480
          EXECUTE SETEOF.(END1)                                                1490
          NOCOL=0                                                              1500
          J=PELT(I+3)                                                          1510
RDCOL     J1=J+J2-1                                                            1520
          COUNT = J1 - J
          READ BINARY TAPE FOUR, B(J)... B(COUNT+J)
          J=J+J2                                                               1540
```

```
            NOCOL=NOCOL+1                                                    1550
            TRANSFER TO RDCOL                                                1560
END1        PELT(I+4)=NOCOL                                                  1570
            PELT(I+8)=PELT(I+3)+J2*NOCOL                                     1580
            WHENEVER PELT(I+8).G.8399.OR.PELT(I+6).G.399                     1590
            COLOVR(6)=PELT(I)                                                1600
            VECTOR VALUES COLOVR=$ELEMENT COLLECTIONS EXCEED STORAGE $,0      1610
            EXECUTE OUTPUT.(COLOVR,7)                                        1620
            IFERR1=1B                                                        1630
            ALLIN = 0B
            TRANSFER TO PRNOUT
            END OF CONDITIONAL                                               1650
LP1         CONTINUE                                                         1660
 PRNOUT     T'H BBLIST ,FOR K=0,1,K.G.PRLCNT-1
 BBLIST      P'T PELTL,PELT(K,0)...PELT(K,4)
            V'S PELTL = $1H C6,S4,4(S2,I12) *$
            EXECUTE OUTPUT.(BREG,8)
            THROUGH BLIST, FOR I=0,1,I.GE. M
            P'T PELTL, PELT(I,0)...PELT(I,4)
            EXECUTE OUTPUT.(ATTHD,3)
            EXECUTE LPRINT.($ $,ATS(PELT(I,1)),PELT(I,2))
            T'H BLIST,FOR K=0,4,K.GE.PELT(I+1,3) - PELT(I,3)
             SUBSC1 = PELT(I,3)+K
             SUBSC2 = PELT(I,3)+K +3
            PRINT FORMAT BITPR,SUBSC1 ,B(PELT(I,3)+K)...B(PELT(I,3)+K+3)
           1,SUBSC2
            V'S BITPR = $1H S4,I12,S4,4(S2,K12),S2,I12*$
BLIST       CONTINUE
            VECTOR VALUES BREG=$ B-REGION. BITS FOR DESIRED RESULTS REDUCTION
           1TION.$
            VECTOR VALUES ATTHD=$ATTACHMENT NAMES.$
            FUNCTION RETURN                                                  1670
           R                                                                 1680
            NORMAL MODE IS INTEGER                                           1690
            DIMENSION ATS(199)                                               1700
                BOOLEAN ALLIN
            EQUIVALENCE (ALLIN,A(15872))
           R                                                                 1710
           R                                                                 1720
           R ** STANDARD PROGRAM COMMON FOR CORE NO.2                        1730
            PROGRAM COMMON A,B                                               1740
            DIMENSION A(15999,DIM1)
            DIMENSION B(1999, PDIM)
           R                                                                 1760
           R   ***COMPILER CONTROL CARDS   ********                         1770
           R                                                                 1780
           R  DEFINITION OF  A(39,0)...A(39,399)                             1790
            VECTOR VALUES A(15600)=$ELTAPE$                                  1800
            EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),             1810
           1            ( A(15603),PARCNT ),( A(15604),ELN    ),             1820
           2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),             1830
           3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),             1840
           4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),             1850
           5            ( A(15843),SCNT   ),( A(15844),ECNT   ),             1860
           6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),             1870
           7            ( A(15848),ID1    ),( A(15849),ID2    ),             1880
           8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )              1890
           9           ,( A(15853),DIM1)                                     1900
            EQUIVALENCE (CKRN,A(15856)),(THREE,A(15857)),(FOUR,A(15858)) CK
```

```
1,          (FIVE,A(15889))                                          CK
 EQUIVALENCE (ATS,A(8600)),  (PELT,A(8200))
 DIMENSION              ELN(95), FPAR(71), ZPAR(69)
 DIMENSION PELT(299,DIM2)
 BOOLEAN IFERR1, TAPEOK                                                1940
 BOOLEAN CKRN
 VECTOR VALUES DIM1 = 2,401,400                                        1090
 VECTOR VALUES DIM2 = 2,6,5
 VECTOR VALUES PDIM = 2,6,5
 EQUIVALENCE (M,A(15864))
 END OF FUNCTION                                                         *
```

```
$ COMPILE MAD,PUNCH OBJECT,PRINT OBJECT                                ERR00000
          EXTERNAL FUNCTION(Z)
          R'N
          ENTRY TO ERR.
          ERRNO = Z
          BOOLEAN RESTAR
          RESTAR = 1B
          EXECUTE OUTPUT.(DFRCOM,18)
          VECTOR VALUES DFRCOM=$ERROR ENCOUNTERED. EOF,ERRNO ON TAPE TH
         1REE. THREE AND FOUR REWOUND. EOF REMOVED FROM FIVE.SYSTEM EXE
         2CUTED.$
          END OF FILE TAPE THREE
          WRITE BINARY TAPE THREE, ERRNO
          CKOUT=BNBCD.(ERRNO)
          EXECUTE OUTPUT.(CKOUT,3)
          DIMENSION CKOUT(2)
          VECTOR VALUES CKOUT(1)=$=ERRNO$
          END OF FILE TAPE THREE
          REWIND TAPE THREE
          W'R RESTAR
          REWIND TAPE FOUR
          READ BINARY TAPE FOUR, IDENT
          W'R IDENT .E. $ELTAPE$
          BACKSPACE RECORD OF TAPE FOUR
          WRITE BINARY TAPE FOUR,$RESTARRESTARRESTARRESTAR$
          EXECUTESKFILE.(FOUR,1)
          WRITE BINARY TAPE FOUR,$RESTARRESTARRESTARRESTARRESTAR$
          E'L
          E'L
          SEQPGM.
          PROGRAM COMMON A,B
          DIMENSION A(15999),B(2000)
          NORMAL MODE IS INTEGER
          VECTOR VALUES THREE= 3
          VECTOR VALUES FOUR = 4
          VECTOR VALUES FIVE = 9
          ERASABLE BLAST
          END OF FUNCTION                                                *
```

```
$COMPILE MAD,EXECUTE,DUMP,PUNCH OBJECT                                  EQVGEN00
          EXTERNAL FUNCTION                                                    10
          R'N
          ENTRY TO EQVGEN.                                                   0280
          PRINT COMMENT  $ EQVGEN$
          R                                                                  290
            THROUGH LISTE, FOR L=0,1,L.GE. ECNT
            PAR = A(15,L)
                              EXECUTE OUTPUT.(OCTDEC.(L),1)                  0330
                              EXECUTE OUTPUT.(PAR,1)                         0340
          R                                                                  350
          OCCURS = 0B                                                        0360
          TEL    = A(16,L)
          TEID   = A(17,L)
          TAT    = A(18,L)
          TAID   = A(19,L)
          EXECUTE SRCHFP.                                                    0410
          EXECUTE SRCHCN.                                                    0420
LISTE     CONTINUE                                                           0430
          FUNCTION RETURN                                                    0440
          INTERNAL FUNCTION                                                  0450
          ENTRY TO SRCHFP.                                                   0460
          R                                                                  0470
          R        CHECK LIST OF PARAMETERS TO SEE IF -PAR- IS ON LIST.       0480
FPARVC    THROUGHFPARVC, FOR I=0,1,I.E. PARCNT .OR. PAR .E. FPAR(I)          0490
          WHENEVER I.L. PARCNT, FUNCTION RETURN                              0500
          VECTOR VALUES FERR = $****THE PARAMETER $,$ $,$ IS NOT ON PAR      0510
          IAMETER LIST$                                                      520
          FERR(3) = PAR                                                      0530
          EXECUTE OUTPUT.(FERR,9)                                            0540
          TRANSFER TO LISTE                                                  0550
          END OF FUNCTION                                                    0560
          INTERNAL FUNCTION                                                  0570
          R  SEARCH BOTH SIDES OF CONNECTIONS LIST                           0580
          ENTRY TO SRCHCN.                                                   0590
            THROUGH CLIST, FOR J=0,1,J.GE. CCNT
          WHENEVER (A34(J)  .E. TAID   .OR.  TAID  .E. $ $ )                 0610
          1.AND.          (A33(J)  .E. TAT     .OR. TAT   .E. $ $ )          0620
          2.AND.          (A32(J)  .E. TEID    .OR. TEID  .E. $ $ )          0630
          3.AND.          (A31(J)  .E. TEL     .OR. TEL   .E. $ $ )          0640
          SIDE =0                                                            650
          TRANSFER TO PRNT                                                   0660
          OR WHENEVER (A38(J)  .E. TAID   .OR.  TAID  .E. $ $ )              0670
          1.AND.        (A37(J)  .E. TAT    .OR.  TAT   .E. $ $ )            0680
          2.AND.        (A36(J)  .E.  TEID  .OR.   TEID .E. $ $ )            0690
          3.AND.         (A35(J) .E.  TEL   .OR.   TEL  .E. $ $ )            0700
          SIDE =1                                                            710
PRNT
          ENUM=BNBCD.(A(27+SIDE,J))
          EQV(7) =OR.(ZPAR(I),ENUM)
                              EXECUTE OUTPUT.(OCTDEC.(J),1)
          EQV (5) = A(14,L)                                                  0740
           EXECUTE OUTPUT.(EQV,9)
          PUNCH FORMAT FORMPU,EQV...EQV(8)
          V'S FORMPU=$9C6*$
          VECTOR VALUES EQV = $ $,$ $,$EQUIVALENCE    ( $,$ $,$  ,$,         0780
          1$ $ ,$ )$                                                         0790
          OCCURS = 1B                                                        0800
          END OF CONDITIONAL                                                 0810
```

```
CLIST      CONTINUE                                                          830
           WHENEVER .NOT. OCCURS, EXECUTE OUTPUT.(NO,10)                    0820
           FUNCTION RETURN                                                  0840
            VECTOR VALUES NO(4)=$ DOES NOT OCCUR ON THE CONNECTION LIST$
           EQUIVALENCE (TEL,NO),(TEID, NO(1)),(TAT,NO(2)),(TAID,NO(3))      0860
           DIMENSION NO(10)                                                 0870
           END OF FUNCTION                                                  0880
           PROGRAM COMMON A                                                  20
           DIMENSION A(15999,DIM1),PCNT(1)                                  0030
           VECTOR VALUES DIM1 = 2,401,400                                    040
           NORMAL MODE IS INTEGER                                           0070
          R  DEFINITION OF  A(39,0)...A(39,399)                             0050
           VECTOR VALUES A(15600)=$ELTAPE$                                  0060
           EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),             0070
          1            ( A(15603),PARCNT ),( A(15604),ELN    ),             0080
          2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),             0090
          3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),             0100
          4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),             0110
          5            ( A(15843),SCNT   ),( A(15844),ECNT   ),             0120
          6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),             0130
          7            ( A(15848),ID1    ),( A(15849),ID2    ),             0140
          8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )              0170
           DIMENSION PELT(300),ELN(95),FPAR(71),ZPAR(69)                    0180
          R EQUIVALENCE OUTPUT GENERATOR                                    0190
           DIMENSION A31(1),A32(2),A33(1),A34(1),A35(1),A36(1),A37(1),      0200
          1A38(1)                                                            210
           DIMENSION   ACOL2(1), ACOL3(1)                                   0220
           EQUIVALENCE (A(12400),A31),(A(12800),A32),(A(13200),A33),        0230
          1(A(13600),A34),(A(14000),A35),(A(14400),A36),(A(14800),A37),     0240
          1(A(15200),A38)                                                   *250
           BOOLEAN OCCURS                                                   0260
          R                                                                  270
           END OF FUNCTION                                                   *
```

```
$ASSEMBLE,PUNCH OBJECT                                          INSRTC00
        ENTRY INSRTC
        ENTRY EXTRC
INSRTC  SLN 1          RSLT = INSRTC.(WORD, J, CHAR)
        CLA     3,4      CHAR IS PLACED IN THE JTH POSITION OF WORD.
        STA CHAR
        SLT 1
EXTRC   SLN 1          RSLT = EXTRC. (WORD, J)
        SXD XRB,2      RSLT IS THE CHARACTER EXTRACTED FROM THE JTH
        CLA*    2,4
        PAX     0,2
        CAL*    1,4
        SLT 1
XRB     TXL IN1,0,0
        LDQ BLANKS
BACK1   TXH OUT1,2,5
        ARS 6
        TXI BACK1,2,1
OUT1    LGL 30
        SLW COMMON
        TXL EXIT,0,0
IN1     SLW COMMON
CHAR    LDQ **
        CAL MASK
        RQL 6
COUNT   TXH OUT2,2,5
        ALS 6
        TXI COUNT-1,2,1
OUT2    STQ COMMON-1
        COM
        ANS COMMON
        COM
        ANA COMMON-1
        ORS COMMON
EXIT    CLA COMMON
        LXD XRB,2
        TRA 3,4
BLANKS  BCD 1
MASK    OCT 000000000077
COMMON  SYN -1
LAST    BSS 0
        END                                                     *
```

```
$ASSEMBLE,PUNCH OBJECT                                    LOGIC.00
        ENTRY AND
        ENTRY NOT
        ENTRY OR
        ENTRY XOR
        ENTRY THEN
        ENTRY EQV
HOOK    CAL*    2,4
        SLW     C-2
HOOK1   CAL*    1,4
        SLW C-1
        TRA 1,2
EQV     TSX HOOK,2
        ORA C-2         W1.OR.W2
        COM             .NOT. (W1.OR.W2)
        SLW C
        CAL C-1
        ANA C-2         W1.AND.W2
        ORS C           (W1.AND.W2).OR.(.NOT.(W1.OR.W2))
        TRA R2
THEN    TSX HOOK,2
        COM             .NOT.W1
        ORA C-2         .NOT.W1.OR.W2
        TRA R1
XOR     TSX HOOK,2
        ANA C-2         W1.AND.W2
        COM             .NOT.(W1.AND.W2)
        SLW C
        CAL C-1
        ORA C-2         (W1.OR.W2)
        ANS C           (W1.OR.W2).AND.(.NOT.(W1.ANDW2)
        TRA R2
NOT     TSX HOOK1,2
        COM             NOT.W1
        TRA R1
OR      TSX HOOK,2
        ORA C-2         W1.ORW2
        TRA R1
AND     TSX HOOK,2
        ANA C-2         W1 AND W2
R1      SLW C
R2      CLA C
        TRA 2,4
LAST    BSS C
C       SYN -1
        END                                                *
```

```
$ASSEMBLE,PUNCH OBJECT                                          LOCATE00
       ENTRY LOCATE
LOCATE CLA*    3,4          LOCATE.(WORD, LIST, COUNT)
       ADD     ONE
       PAX     0,2
       CLA     2,4          LIST ADDRESS PLUS ONE
       STA     COMP2
       ADD ONE
       STA     COMP
       CLA*    1,4          WORD
COMP2  CAS     **
       TRA     COMP
       TRA     FIRST
COMP   CAS     **,2
       TIX     *-1,2,1
       TRA     EQUAL
       TIX     *-3,2,1
EQUAL  PXA     0,2          WORD FOUND AT THIS LOCATION PLUS 1
       SUB     ONE          IF WORD NOT ON LIST ACCUMULAROR WILL BE NEG
       TNZ     4,4
       SUB     ONE
       TRA     4,4
FIRST  CLA     ZERO
       TRA     4,4
ZERO   PZE     0
       TRA     4,4
ONE    PZE  1
       END                                                                *
```

```
$COMPILE MAD,PUNCH OBJECT,PRINT OBJECT                          LPRINT.0
            EXTERNAL FUNCTION(HEAD, LIST, COUNT)
            ENTRY TO LPRINT.
            K= 12
            EXECUTE OUTPUT.(HEAD,1)
            THROUGH A, FOR I=0,12, I.GE. COUNT
            WHENEVER COUNT-I.LE. 12, K= COUNT-I
A           EXECUTE OUTPUT.(LIST(I),K)
            FUNCTION RETURN
            ENTRY TO DPRINT.
            K=12
            EXECUTE OUTPUT.(HEAD,1)
            THROUGH B, FOR I=0,12, I.GE. COUNT
            WHENEVERCOUNT-I.LE. 12, K= COUNT -I
            THROUGH C, FOR J=I,1, J.GE. K
 C          LINE(J) = LIST(J)
B           EXECUTE OUTPUT.(LINE(I),K)
            FUNCTION RETURN
            NORMAL MODE IS INTEGER
            DIMENSION LINE(12)
            PROGRAM COMMON A
            DIMENSION A(15999)
            EQUIVALENCE (A(15858), FOUR),(A(15601), PELCNT),
           1            (A(15602),TELCNT),(A(15603),PARCNT)
            EQUIVALENCE(A(15700),FPAR),(A(15772),ZPAR )
           1,(A(15604),ELN)
            END OF FUNCTION                                     *
```

```
$ASSEMBLE,PUNCH OBJECT                                          OCTDEC00
        ENTRY OCTDEC
        ENTRY D                                                      CK
D       NOP                                                          CK
OCTDEC  CLA*    1,4
        TNZ     *+3
        CLA     BZP
        TRA     2,4
        SLW OCTINT
        SXA     IRA,1
        TMI MI
        CLA BZP
        TRA STO
MI      CLA BZM
STO     STO WORD
        CLA     OCTINT
        SUB     =9999
        TMI     *+3
        CLA     LARGE
        TRA     2,4
        LXD THREE,1
        SLN 1
BACK    CLA TEN
        LDQ OCTINT
        TLQ FINI
        PXD 0,0
        DVP TEN
        STQ OCTINT
BACK2   ORS WORD
        LDQ WORD
        RQL 30
        STQ WORD
        TIX BACK,1,1
FINI2   LDQ WORD
        TXH RTN,1,3
        RQL 6
        TXI *-2,1,1
RTN     STQ WORD
        CLA WORD
IRA     AXT     **,1
        TRA 2,4
FINI    SLT 1
THREE   TXL FINI2,0,3
        CLA OCTINT
        TXI BACK2,1,1
WORD    SYN -1
OCTINT  SYN -2
TEN     PZE 10                  CORRECTION TO OCTDEC
LARGE   BCD 1*LARGE
BZP     BCD 1 + 000
BZM     BCD 1 - 000
LAST    BSS 0
        END                                                                  *
```

```
$ASSEMBLE,PUNCH OBJECT                                    OCT.0000
        ENTRY OCT
OCT     CLA     1,4
        SXA     IRA,1
        STA L1
        CLA 2,4
        STA S1
        SSP
        SUB CNE
        STA CUT
L1      LDQ **
        SLN 1
S1      STO **
        LXA A=6,1
T1      ALS 3
        LGL 3
        TIX T1,1,1
        SLT 1
        TRA *+2
        TRA S1
OUT     STO **
IRA     AXT     **,1
        TRA 3,4
A=6     PZE 6,0,0
ONE     PZE 1
LAST    BSS 0
        END                                                *
```

```
$ASSEMBLE,PUNCH OBJECT                                                  OUTPUT00
        ENTRY OUTPUT                                                              730
        ENTRY OUTPT
        ENTRY OUT                                                          CK
OUTPT   NOP
OUT     NOP                                                                CK
OUTPUT  CLA     1,4             EXECUTE OUTPUT.(NAME,COUNT)                       740
        STA     OT                                                                750
        LDQ     =20
        CLA*    2,4                                                               760
        TLQ     THEAXE
XRC     PAX     0,3                                                               770
        TXI     *+1,1,1
        SXD     LG,1                                                       CK
        TXI     *+1,1,C   ADD.OF C IS ADD. OF D MINUS ONE                  CK
        SXA     ST,1                                                              810
        AXT     0,1                                                               820
OT      CLA     **,1                                                       CK
ST      STO     **,2  PICK UP FROM NAME REGION,STORE IN D BUFFER-FORWARD   CK
        TXI     *+1,1,1                                                           850
        TIX     OT,2,1                                                            860
        SXA     XRC,4                                                             870
        CALL    SPRINT                                                            880
LG      BLK     C,,**                                                      CK
        LXA     XRC,4                                                             900
        TRA     3,4                                                               910
THEAXE  CALL    SPRINT
        BLK     PAGE,,N
        CALL    SYSTEM
ONE     PZE     1
N       PZE     0,,0
        CLA     COUNT           LINES OF OUTPUT
        SUB     ONE
        TMI     THEAXE
        STO COUNT
COUNT   PZE     250
PAGE    BCD 91  MAXIMUM OF 250 LINES OF OUTPUT PER JOB EXCEEDED. SOR
        BCD 5RRY MAC...YOU ARE BEING  CUT OFF.
C       BCD 10                                                                    920
D       BSS     20                                                                930
        END                                                                        *
```

```
$COMPILE MAD,PRINT OBJECT,PUNCH OBJECT                                  OUTPT100
            EXTERNAL FUNCTION(X)
                ENTRY TO OUTPT1.
            EXECUTE OUTPUT.(CKH,2)                                          CK
            VECTOR VALUES CKH=$*OUTPT1. SUBROUTINES$                        CK
           R (**ARGUMENT X IS NUMBER OF COLUMNS TO BE PUNCHED.)
            XX=X
            WHENEVER EXTRC.(BFR(1),5)  .F. $R$, FUNCTION RETURN
                EXECUTE PNCH12.(BFR1)
                 EXECUTE OUTPUT.(BFR1,12)
            WCNT= 11
            WORDS = (XX-1)/6
            THRO U GH LIST, FOR J=1,1, WCNT.GE. WORDS .OR. J.G. 9
            BFR1(WCNT+2)= INSRTC.(BFR1(WCNT+2),5, NUM(J))
            VECTOR VA LU ES NUM=$1$,$2$,$3$,$4$,$5$,$6$,$7$,$8$,$9$
            EXECU TE OUTPUT.(BFR1(WCNT+1),12)
            EXECUTE PNCH12.(BFR1(WCNT+1))
LIST        WCNT = WCNT + 12
            FUNCTION RETURN
            DIMENSION A(15999)
            PROGRAM COMMON A
            NORMAL MODE IS INTEGER
            EQUIVALENCE (A(5320),BFR1),(A(5200),BFR   )
            DIMENSION BFR1(120),BFR(120)
            EQUIVALENCE (T(265),CCA(0))
             EQUIVALENCE (CCA,J2)
            EQUIVALENCE (T(0),A(15600))
            END OF FUNCTION                                                 *
```

```
$COMPILE MAD,PRINT OBJECT,PUNCH OBJECT                                  PELTOT00
            EXTERNAL FUNCTION (COUNT)
             ENTRY TO PELTOT.
            EXECUTE OUTPUT. ($PELTOT$,1)
            K=0
            NORMAL MODE IS INTEGER
            EXECUTE OUTPUT.(PRIN1,4)
            VECTOR VALUES PRIN1 = $ PRESENT ELEMENT TABLE $
P           CONTINUE
            EXECUTE OUTPUT.(PRIN2,6)
            VECTOR VALUES PRIN2 = $ ELN FSTAT NOATS FSTSC NOCOL $
            TRANSFER TO S(K)
S(0)        CONTINUE
            T'H PRIN6, FORI=0,1,I.G. COUNT
            OUTPUT.(PELT(I,0),5)
 PRIN6      CONTINUE
             FUNCTION RETURN
            ENTRY TO PELTLN.
            EXECUTE OUTPUT.($PELTLN$,1)
            K=1
            I= COUNT
            TRANSFER TO P
S(1)        CONTINUE
            THROUGH PRIN4,FOR I = 0,1,I.G.PRLCNT
            EXECUTE OUTPUT.(PELT(I*5),5)
PRIN4       CONTINUE
            FUNCTION RETURN
                ENTRY TO ELNOUT.
            EXECUTE OUTPUT.($ELNOUT$,1)
            EXECUTE OUTPUT.(PRIN3,3)
            VECTOR VALUES PRIN3 = $ ELEMENT NAMES $
            EXECUTE OUTPUT.(ELN(0),COUNT)
             FUNCTION RETURN
            PROGRAM COMMON A,B
            EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),              1810
           1            ( A(15603),PARCNT ),( A(15604),ELN    ),              1820
           2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),              1830
           3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),              1840
           4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),              1850
           5            ( A(15843),SCNT   ),( A(15844),ECNT   ),              1860
           6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),              1870
           7            ( A(15848),ID1    ),( A(15849),ID2    ),              1880
           8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )               1890
           9           ,( A(15853),DIM1)                                      1900
            EQUIVALENCE (CKRN,A(15856)),(THREE,A(15857)),(FOUR,A(15858)) CK
           1,           (FIVE,A(15889))                                    CK
            EQUIVALENCE (ATS,A(8600)),  (PELT,A(8200))
             DIMENSION A(15999),PELT(400),ELN(95)
            DIMENSION B(1999,PDIM2)
            VECTOR VALUES PDIM2 = 2,6,5
             EQUIVALENCE(PELT,A(8200)),(ELN,A(15604))
            EQUIVALENCE (M,A(15864))
            END OF FUNCTION                                                    *
$ASSEMBLE,PUNCH OBJECT                                                  PLACE000
      ENTRY PLACE       CALLING SEQUENCE EXECUTE PLACE.(A(N),L,$B$)
PLACE NOP
 IN   CLA     1,4
      ADD     IN
      STA     BASE
```

```
        CLA*    2,4
        PAX     0,1
        CAL*    3,4             SIX CHARACTER WORD TO BE STORED IN
BASE    SLW     **,1      A(N),...,A(L)
        TIX     BASE,1,1
        TRA     4,4
        END
```

```
$COMPILE MAD,EXECUTE,DUMP,PUNCH OBJECT ,PRINT OBJECT                    PSCAN000
          EXTERNAL FUNCTION
          ENTRY TO PSCAN.
          M=0
          CARDS = 0
 READ     READ BINARY TAPE UNIT, BFR(M),...,BFR(M+11)
          CHAR= EXTRC.(BFR(M+1),5)
          WHENEVER CHAR.E. $R$
DOLLAR
          PUNCH FORMAT FORMPU,BFR(M)...BFR(M+11)
          V'S FORMPU = $ 12C6*$
               TRANSFER TO READ
          O'R CHAR.E.$$.OR.(CHAR.GE.$0$.AND.CHAR.LE.$9$)
          COL1=EXTRC.(BFR(M),1)
          W'R COL1.E. -$=$, T'O DOLLAR
          WHENEVER COL1.E.$+$.OR. COL1.E.$-$
                BFR(M)= INSRTC.(BFR(M),1,$ $)
               WHENEVER COL1.E. $+$
                   PLSFLG= 1B
               OTHERWISE
                    MINFLG= 1B
               END OF CONDITIONAL
          PUNCH FORMAT FORMPU,BFR(M)...BFR(M+11)
          T'O SCANS
          OTHERWISE
          PUNCH FORMAT FORMPU,BFR(M)...BFR(M+11)
          T'O READ
          E'L
          OTHERWISE
          PRINT COMMENT $ THIS CARD NOT PUNCHED $
          OUTPUT.(BFR(M),12)
          E'L
 SCANS    FUNCTION RETURN
          PROGRAM COMMON A,B
          D'N DIM1(2)
          DIMENSION A(15999,DIM1),PELT(299,PDIM),T(300),ATTNO(50)
         1,BFR(200),FPAR(71),ZPAR(69),B(1999 ,PDIM),PCNT(1)
          EQUIVALENCE (T,A(15600)),(A(6600),BFR),(T(276),RCNO)
         1,(T(  3),PNUMBR),(T(245),IPCNT ),(T(246),DRPCNT)
         2,(T(247),FSCNT  ),(T(253),DIM1  ),(T(256),ERRNO  )
         3,(T(257),THREE ),(T(258),FOUR  ),(T(263),FSUBIN)
         4,(T(264),M     ),(T(265),CCA   ),(T(266),CARDS )
         5,(T(267),MA    ),(T(268),EPFLG ),(T(269),EPCNT )
         6,(T(270),MCOUNT),(T(271),REM   ),(T(272),BOOLN )
          EQUIVALENCE(T(273),UNIT) ,(T(294),LOCLBL)
         7,(T(274),PXSIT ),(T(275),LINE  ),(T(277),J     )
         8,(T(278),I3    ),(T(279),I2    ),(T(284),LBWORD)
         9,(T(287),MINFLG),(T(288),PLSFLG),(T(289),FIVE  )
         1,(T(290),SLBFLG),(T(291),FINFLG),(T(292),J1)
         6,(A( 7100),ATTNO ),(A( 8200),PELT)
          NORMAL MODE IS INTEGER
          BOOLEAN  IFERR1, CKRN, FUBSIN,EPFLG, MCOUNT, BOOLN
         1,ONCEB,  ONCEBB,MINFLG,PLSFLG,SLBFLG,FINFLG,EOFBLN,SCANDL
           BOOLEAN ELFLG, CCOUNT
          VECTOR VALUES PDIM=2,6,5
           EQUIVALENCE (CCA,J2),(T(260),EOFBLN),(RCNO,RCNO)
          EQUIVALENCE(PARCNT,PNUMBR)
          END OF FUNCTION                                                *
```

```
$ASSEMBLE,PUNCH OBJECT,PRINT OBJECT                                    SEARCH00
*************************************************************************
*       SEARCH  SIMULATOR CORE4                                BOYD NOV 64
*       CALLED BY SSCAN1
*
*       ROUTINE TO SEARCH A LIST LOOKING FOR A SPECIFIC ENTRY
*       RETURNS IN AC LIST SUBSCRIPT WHERE ENTRY IS FOUND
*       IF THE SAME ENTRY OCCURS MORE THAN ONCE ONLY THE LAST WILL BE FOUN
*
*       ARGUMENTS
*       1,4     ZERO LOCATION OF LIST
*       2,4     LAST ENTRY ON LIST
*       3,4     WORD TO BE FOUND
*       4,4     EXIT IF ENTRY NOT FOUND
*
*       CALLED FROM SSCAN1 TO SCAN FPAR LIST FOR VARIABLE NAMES, SO THAT
*       THE UNIQUE THREE CHARACTER NAME CAN BE FOUND ON THE ZPAR LIST
*
*************************************************************************
       ENTRY SEARCH
SEARCH CLA     1,4                  ZERO LOCATION
       STA     CAS
       CLA*    2,4                  LAST ENTRY
       PAX     ,1
       CLA*    3,4
CAS    CAS     **,1
       TRA     *+2
       TRA     OUT                  WORD FOUND
       TIX     CAS,1,1              LOOP TO SEARCH BACKWARDS
       AXT     0,1
       CAS*    CAS                  CHECK ZERO LOCATION
       TRA*    4,4                  WORD NOT FOUND,  ERROR RETURN
       TRA     *+2
       TRA*    4,4                  WORD NOT FOUND,  ERROR RETURN
OUT    PXA     ,1                   WORD FOUND, PUT INDES IN AC
       TRA     5,4                  NORMAL RETURN
       END                                                            *
```

```
$CPMPILE MAD, PRINT OBJECT, PUNCH OBJECT                              SNOW000
          EXTERNAL FUNCTION
          ENTRY TO SNOW.


          R         ROUTINE TO RECORD THE FIRST OCCURENCE AND FUTURE
          R         OCCURENCES OF ALL ATTACHMENTS


          N'S INTEGER
          P'R F(200)
          D'N CONL(F),CONR(F),BROAD(F)
          PROGRAM COMMON A(15999),B(1999),BROAD(F)


          R         ************************************************************

          DEFINE UNARY OPERATOR .M., PRECEDENCE SAME AS .E.
          MODE STRUCTURE 2 = .M. 1
     CLA      B
     TMI      LOC+3
     PXA      ,0
     TRA      LOC+2
     CLA      =1
     OUT      AC
     END
          DEFINE UNARY OPERATOR .STZ., PRECEDENCE SAME AS =
          MODE STRUCTURE .STZ. 1
     STZ      B
     OUT      Z
     END
          MODE STRUCTURE .STZ.2, SAME SEQUENCE AS .STZ.1

          R         ************************************************************

          R          CCONT = THE NO. OF LINES IN THE CONNECTIONS MATRIX
          R          CONL =  LEFT HALF OF THE CONNECTIONS MATRIX
          R          CONR = RIGHT HALF OF THE CONNECTIONS MATRIX
          R          BROAD = THE END RESULT OF THIS ROUTINE


          .STZ. BROAD
          T'H SEEK, FOR Q = 1, 1, Q .GE. CCONT
          QP = Q - 1
          FIRST = BLB.(SUCH,CONL(Q))
          SECOND = BLB.(NOISE,CONR(Q))
          BOOLEAN NOISE, SUCH
          W'R FIRST .L. SECOND

          R         SAVE THE SMALLEST SUBSCRIPT AND THEN REPLACE THE
          R         OCCURENCES OF THE LARGER, IF THERE ARE ANY, BY THE
          R         SMALLER IN THE BROAD ARRAY

          BROAD(Q) = FIRST
          W'R NOISE .AND. (SECOND .NE. Q), FAKED.(SECOND)
          C'R SECOND .L. FIRST
          BROAD(Q) = SECOND
          W'R SUCH .AND. (FIRST .NE. Q), FAKED.(FIRST)
          C'E
```

```
          BROAD(Q) = FIRST
          E'L
SEEK
          F'N
          INTERNAL FUNCTION(NUMB)
          E'O FAKED.

         R        FUNCTION TO FIND AND REPLACE THE OCCURENCES OF A
         R        NUMBER

          (QP=QP,-1,QP .L. 0, QP = SEARCH.(BROAD,QP,NUMB,SEEK),BROAD
         1(QP) = FIRST)
          T'O SEEK
          E'N
          EQUIVALENCE (CONR,A(6000)),(CONL,A(5600)),(CCNT, A(15842))
          EQUIVALENCE (CCONT,CCNT)
          INTERNAL FUNCTION (MUNCH,CON)
          E'O BLB.
          W'R .M. CON
          MUNCH = 1B
          BOOLEAN MUNCH
          F'N BROAD(SEARCH.(CONR,QP,CON,NEWL))
          C'E
          .STZ. MUNCH
SAME
          F'N Q
          E'L
NEWL
          F'N BROAD(SEARCH.(CONL,QP,CON,SAME))
          E'N
          E'N
```

```
$COMPILE MAD, PRINT OBJECT,PUNCH OBJECT                                SQUEEZ000
          EXTERNAL FUNCTION
          R'N
          E'O SQUEEZ.
         R        FUNCTION TO COMPRESS CONECTIONS MATRIX


         ROPERATOR TO STORE SUBSCRIPTS INTO A 9 BIT PACKAGE IN THE
         RPRODUT VECTOR
         R(ARRANGED AS FOLLOWS ... /ATT ID/ ELM ID/ ATT/ ELN/)


          DEFINE UNARY OPERATOR .SQUEEZ., PRECEDENCE HIGHER THAN =
          MODE STRUCTURE .SQUEEZ.1
       PXA      ,0
       AXT      3,4
       LGL      9
       ADD      =SUB+1,4
       TIX      LOC-2,4,1
       STO      B
       OUT      Z
       END


          IQ = 0
          ID1 = $$
          LONG=1
          SQUEAK.(LFT ELM, LFTATT,L ELM ID,L ATT ID, CON L)
          SQUEAK.(RIT ELM,RIT ATT, R ELM ID, R ATT ID, CON R)
          F'N




          INTERNAL FUNCTION (ELEMNT,ATMNT,ELM ID,ATT ID, PRODUT)
          E'O SQUEAK.


          T'H HALF, FOR I=0,1, I .GE. CCNT
          SUB = SEARCH.(ELMNO,NUMBER-1,ELEMNT(I),MISING(IQ))
         R      SUB = SUBSCRIPT OF ELEMENT IN ELN MATRIX
          BEGIN=SUB*5+1
          SUB(2) = SEARCH.(ATTMNT(PELT(BEGIN)),PELT(BEGIN+1)-1,ATMNT(I)
         1,MISING(IQ))
         R                    SUB(2) = SUBSCRIPT OF ATTACHMENT IN ATS MATRIX
          SUB(1) = SEARCH.(ID1,LONG-1,ELM ID(I),ADD)
         R                    SUB(1) = SUBSCRIPT OF ELEMNT IDENTIFER IN
         R                             THE UNIQUE LIST OF IDENTIFERS
         R              UNIQUE LIST OF IDENTIFIERS
GO ON
          SUBR=SEARCH.(ID1,LONG-1,ATT ID(I), ADD1)
         R         SUBR= SUBSCRIPT OF ATTACHMENT IN UNIQUE LIST OF
         R              IDENTIFIERS
QUIK
          .SQUEEZ. PRODUT(I)
          W'R SUBR .G. 0, PRODUT(I)= - PRODUT(I)
HALF
```

```
          F'N
ADD
         R        TO HERE IF THE ELM ID NOT YET ON THE LIST
          ID1(LONG) = ELM ID(I)
          SUB(1)=LONG
          LONG = LONG + 1
          T'O GO ON
ADD1
         R        TO HERE IF THE ATT ID NOT YET ON THE LIST
          ID1(LONG) = ATT ID(I)
          SUBR=LONG
          LONG = LONG + 1
          T'O QUIK
MISING    P'T $H86*****  ERROR -- COULD NOT FIND ONE OF THE FOLLOWING N
         1AMES/LINE(S)8*$
          IQ = 1
         R        TO HERE IF THE ELEMENT IS NOT IN THE ELN OR PELT
         R             VECTORS
MISING(1)  P'T $1H C6,5H, OR C6*$,ELEMNT(I),ATMNT(I)
          PRODUT(I) = 0
          T'O HALF
          E'N


          N'S INTEGER
          D'N SUB(2)
          PROGRAM COMMON A(15999)
          EQUIVALENCE (LFTELM,A(12400)),(LFTATT,A(13200)),
         1        (LELMID,A(12800)),(LATTID,A(13600)),(RITELM,A(14000))
         2       ,(RITATT,A(14800)),(RELMID,A(14400)),(RATTID,A(15200))
         3       ,(CCNT,A(15842)),(ELMNO,A(15604)),(NUMBER,A(15851)),
         4        (ATTMNT,A(8600)),(PELT,A(8200))
         5       ,(CONL,A(5600)),(CONR,A(6000))
          PARAMETER L(399),N(95),M(199),R(299),U(399)
          D'N LFT ELM(L),LFT ATT(L), L ELM ID(L), L ATT ID(L),
         1RIT ELM(L), RIT ATT(L), R ELM ID(L), R ATT ID(L)
          D'N ELMNO(N), ATTMNT(M), PELT(R), ID1(U)
          DIMENSION CONL(L),CONR(L)
          E'N                                                          *
$COMPILE MAD,PUNCH OBJECT,PRINT OBJECT                          SSORDR00
          EXTERNAL FUNCTION                                          10
          R'N
          ENTRY TO SSORDR.                                           20
          PRLCNT=0                                                   30
          ELCNT=PELCNT+TELCNT-1                                      40
          EXECUTE ELNOUT.(ELCNT+1)
         R                                  ELN,LINENO ARE SCRATCH  0050
          T'H LOOPHH,FOR VALUES OF RL = 31,35
          THROUGH LOOPH, FOR I=0,1,I.GE.  CCNT
          ELEMI = A(RL,I)
          THROUGH LOOPI,FOR J=0,1,J.G.ELCNT                          0070
LOOPI     W'R ELEMI.E.ELN(J),T'O LOOPH
          VECTOR VALUES ERR2=$ ELEMENT DESCRIPTION NOT AVAILABLE $,$ $ 0190
          ERR2(6)=ELEMI
          EXECUTE OUTPUT.(ERR2,7)                                    0210
          IFERR1=1B                                                  0220
LOOPH     CONTINUE                                                   0230
 LOOPHH   CONTINUE
          PRLCNT=PELCNT+TELCNT
```

```
          THROUGH LOOPA,FOR VALUES OF RL=31,35                              0410
          RLMOD = RL/35
          TELID=0                                                           420
          THROUGH LOOPB, FOR J=0,1, J.GE. PRLCNT
          LNO=0                                                             440
          ELID=0                                                            450
          ELNJ =  PELT(5*J)
          THROUGH LOOPC, FOR I=0,1,I.GE. CCNT
          WHENEVER A(RL,I).NE.ELNJ, TRANSFER TO LOOPC
          LINENO(LNO)=I                                                     0480
          LNO=LNO+1                                                         0490
          EIDA = A(RL+1,I)
LOOPD     THROUGH LOOPD, FOR K=0,1,K.GE.ELID.OR.EIDA.E. EID(K)
          WHENEVER K.GE. ELID
          EID(ELID) = EIDA
          ELID=ELID+1                                                       0530
          END OF CONDITIONAL                                                0540
LOOPC     CONTINUE                                                          550
          RL1= RL+1
          THROUGH LOOPG, FOR I1=TELID,1,I1.GE. TELID+LNO
          THROUGH LOOPG, FORI2=0,1, I2.GE.  ELID
          EID1= EID(I2)
          THROUGH LOOPG, FOR I3=0,1, I3 .GE. LNO
          WHENEVER A(RL1, LINENO(I3)).NE. EID1,  TRANSFER TO LOOPG
          A(27+ RLMOD,I1) = LINENO(I3)
          I1=I1+1                                                           610
LOOPG     CONTINUE                                                          0620
LOOPB     TELID=I1                                                          0630
LOOPA     CONTINUE                                                          0640
         R          **  R AND L ARE ORDERED                                0650
          THROUGH LOOPZ,FOR VALUES OF RL=31,35                              0660
          RLMOD = RL/35
          THROUGH LOOPZ, FOR I=0,1,I.GE. CCNT
          SUB1 =A(27+RLMOD,I)
          EL1=A(RL,SUB1)                                                    0690
          ID1=A(RL+1,SUB1)                                                  0700
           THROUGH LOOPW, FOR J=0,1,J.GE. CCNT
          SUB2=A(28-RLMOD,J)
          EL2  =A(35-4*RLMOD,SUB2)
          ID2  =A(36-4*RLMOD,SUB2)
          WHENEVER EL1.E.EL2.AND.ID1.E.ID2                                  0750
OUT1      A(29+RLMOD,I) = J
          TRANSFER TO LOOPZ                                                 0770
          END OF CONDITIONAL                                                0780
LOOPW     CONTINUE                                                          0790
          THROUGH LOOPV, FOR J=0,1, J.GE. CCNT
          SUB3 = A(27 +RLMOD,J)
          EL3=A(RL,SUB3)                                                    0820
          ID3=A(RL+1,SUB3)                                                  0830
          WHENEVER EL1.E.EL3.AND.ID1.E.ID3                                  0840
          J=-J                                                              0850
          TRANSFER TO OUT1                                                  0860
          END OF CONDITIONAL                                                0870
LOOPV     CONTINUE                                                          0880
LOOPZ     CONTINUE                                                          0890
          FUNCTION RETURN                                                   0900
          EQUIVALENCE (A(8400),LINENO),(A(8800),EID)                        0910
          DIMENSION EID(400),LINENO(400)                                    0920
         R                                                                  930
```

```
R                                                                        940
R                                                                        950
R                                                                        960
R   ***COMPILER CONTROL CARDS   ********                               0970
R                                                                        980
R  DEFINITION OF  A(39,0)...A(39,399)                                   0990
 VECTOR VALUES A(15600)=$ELTAPE$                                        1000
 EQUIVALENCE ( A(15601),PELCNT ),( A(15602),TELCNT ),                   1010
1            ( A(15603),PARCNT ),( A(15604),ELN    ),                  1020
2            ( A(15700),FPAR   ),( A(15772),ZPAR   ),                  1030
3            ( FPAR(70),SCOPB1 ),( FPAR(71),SCOPB2 ),                  1040
4            ( A(15852),TAPEOK ),( A(15842),CCNT   ),                  1050
5            ( A(15843),SCNT   ),( A(15844),ECNT   ),                  1060
6            ( A(15845),PCNT   ),( A(15847),FSCNT  ),                  1070
8            ( A(15850),IFERR1 ),( A(15851),PRLCNT )                   1090
9           ,( A(15853),DIM1)                                          1100
 DIMENSION PELT(299,DIM2),ELN(95),FPAR(71),ZPAR(69)
 V'S DIM2 = 2,6,5
 EQUIVALENCE (ATS,A(8600)),  (PELT,A(8200))                             1130
 VECTOR VALUES DIM1 = 2,401,400                                         1140
 NORMAL MODE IS INTEGER                                                 1150
 DIMENSION A(15999,DIM1),PCNT(1)                                        1160
 BOOLEAN IFERR1, TAPEOK                                                 1170
 PROGRAM COMMON A                                                       1180
R                                                                       1190
R                                                                       1200
 E'N                                                                     *
```

```
$ASSEMBLE,PUNCH OBJECT                                    TAPE1000
        ENTRY   SKFILE
        ENTRY   SKRECD
        ENTRY   BKSPCE
SKFILE  AXT     0,1
        TRA     START1
SKRECD  AXT     1,1
START1  CLA*    2,4
        TZE     3,4
        TMI     BACKS
        STA     BLK1
        CLA     TYPE,1
        STA     CALL
        CLA*    1,4
        PAX     0,1
        SXD     BLK1,1
        SXA     XRC1,4
CALL    TSX     **,4
BLK1    BLK     **,,**
XRC1    AXT     **,4
        TRA     3,4
        CALL    SKPREC
TYPE    CALL    SKPFIL
BKSPCE  AXT     1,1
        CLA*    2,4
        TZE     3,4
BACKS   PAX     0,2
        CLA     TYPE2,1
        STA     CALL2
        CLA*    1,4
        PAX     0,1
        SXD     BLK2,1
        SXA     XRC2,4
CALL2   TSX     **,4
BLK2    BLK     **,,**
        TIX     *-2,2,1
XRC2    AXT     **,4
        TRA     3,4
        CALL    BSRTAP
TYPE2   CALL    BSFTAP
        END                                                *
```

```
$ASSEMBLE,PUNCH OBJECT                                          TEMPC200
        ENTRY IDSET
        ENTRY PNCH
        ENTRY   PNCH12
PNCH    NOP
PNCH12  NOP
IDSET   CLA     CK
        TZE     1,4
        SXA     IRC,4
        CALL    SPRINT
        BLK     WORD,,7
        STZ     CK
IRC     AXT     0,4
        TRA     1,4
WORD    BCD 78( PNCH,PNCH12, IDSET ARE DUMMY ROUTINES.)
QPQ     CALL    SPRINT
        BLK     ERR,,8
        CALL    SYSTEM
ERR     BCD 78(QPQQSUBROUTINE ILLEGALLY ENTERED.SYSTEM EXEQ.)
  CK    PZE
        END                                                     *
```

```
$ASSEMBLE,PUNCH OBJECT                                                    SYS/ER00
        ENTRY   SYSTEM,ERROR
SYSTEM  NOP
ERROR   PXA     0,4
        PAC     0,4
        SXA     IN,4
        PRINT   FORMAT,IN,0
        CALL    PANEL
       8CALL    SDUMP,10000,,,,77777
        CALL    SELRCD
        BLK     1,,2
IN      PZE
FORMAT  BCI     *,H*6SYSTEM/ERROR CALLED FROM  *,K5*
        END                                                                                    *
```

```
$COMPILE MAD,EXECUTE, PRINT OBJECT,PUNCH OBJECT,DUMP,I/O DUMP   CORE3000CORE3000
          R    SYSTEM SIMULATOR   -   CORE 3.
           R'N
          RDEFINED OPERATORS.
           DEFINE BINARY OPERATOR .NID., PRECEDENCE SAME AS .NE.
           MODE STRUCTURE 2 = 1 .NID. 1
       JMP      *+1,AC,*+2
       STO      T
       JMP      *+1,MQ,*+2
       STQ      T
       JMP      *+1,LA,*+2
       SLW      T
       CAL      A
       LAS      B
       TRA      LOC+2
       TRA      LOC+3
       CLA      =1B
       TRA      LOC+2
       CLA      =0B
       OUT      AC
       END
          ROPERATOR TO TEST FOR PARAMETER BITS.
           DEFINE BINARY OPERATOR .FPAR., PRECEDENCE SAME AS .E.
           MODE STRUCTURE 2=1 .FPAR. 1
       JMP      *+1,AC,*+2
       STO      T
       JMP      *+1,MQ,*+2
       STQ      T
       JMP      *+1,LA,*+2
       SLW      T
       CAL      B
       ARS      2
       ORA      A
       TZE      LOC+2
       CLA      =1B
       OUT      AC
       END
           DEFINE UNARY OPERATOR .ELPOS., PRECEDENCE SAME AS .ABS.
           MODE STRUCTURE 1= .ELPOS. 1
       JMP      *+1,AC,*+2
       STO      T
       JMP      *+1,MQ,*+2
       STQ      T
       CAL      B
       ANA      =777K
       OUT      AC
       END
           DEFINE UNARY OPERATOR .EIDPOS., PRECEDENCE SAME AS .ELPOS.
           MODE STRUCTURE 1= .EIDPOS. 1
       JMP      *+1,AC,*+2
       STO      T
       JMP      *+1,MQ,*+2
       STQ      T
       CAL      B
       ANA      =777K3
       ARS      9
       OUT      AC
       END
           DEFINE UNARY OPERATOR .ATPOS., PRECEDENCE SAME AS .ELPOS.
```

```
     MODE STRUCTURE 1= .ATPOS. 1
JMP      *+1,AC,*+2
STO      T
JMP      *+1,MQ,*+2
STQ      T
CAL      B
ANA      =777K6
ARS      18
OUT      AC
END
     DEFINE UNARY OPERATOR .ANEG., PRECEDENCE SAME AS .ABS.
     MODE STRUCTURE 2= .ANEG. 1
JMP      *+1,AC,*+2
STO      T
JMP      *+1,MQ,*+2
STQ      T
CLA      B
TMI      LOC+3
CLA      =0B
TRA      LOC+2
CLA      =1B
OUT      AC
END
     DEFINE BINARY OPERATOR .COUNT., PRECEDENCE SAME AS *
     MODE STRUCTURE 1=1 .COUNT. 1
JMP      *+1,AC,*+2
STO      T
JMP      *+1,MQ,*+2
STQ      T
JMP      *+1,LA,*+2
SLW      T
CLA      A
STO      =Z1
CLA      B
STO      =Z2
AXT      0,1
AXT      36,2
CAL      =Z1
TSX      LOC+5,4
CAL      =Z2
ARS      2
AXT      34,2
AXC      LOC+6,4
LBT
TRA      LOC+2
TXI      LOC+1,1,1
ARS      1
TIX      LOC-4,2,1
TRA      1,4
PXA      0,1
OUT      AC
END
     DEFINE BINARY OPERATOR .IND., PRECEDENCE SAME AS +
     MODE STRUCTURE 1= 1 .IND. 1
JMP      *+1,AC,*+2
STO      T
JMP      *+1,MQ,*+2
STQ      T
JMP      *+1,LA,*+2
```

```
        SLW     T
        CLA     A
        STO     =Z1
        CLA     B
        PAX     0,4
        SXD     =Z1,4
        CLA     =Z1
        OUT     AC
        END
            DEFINE UNARY OPERATOR .DECR., PRECEDENCE SAME AS .ABS.
            MODE STRUCTURE 1= .DECR. 1
        JMP     *+1,AC,*+2
        STO     T
        JMP     *+1,MQ,*+2
        STQ     T
        JMP     *+1,LA,*+2
        SLW     T
        CLA     B
        PDX     0,4
        PXA     0,4
        OUT     AC
        END
            DEFINE UNARY OPERATOR .ADR., PRECEDENCE SAME AS .ABS.
            MODE STRUCTURE 1= .ADR. 1
        JMP     *+1,AC,*+2
        STO     T
        JMP     *+1,MQ,*+2
        STQ     T
        JMP     *+1,LA,*+2
        SLW     T
        CAL     B
        PAX     0,4
        PXA     0,4
        OUT     AC
        END
           RINITIALIZATIONS.
            PRINT COMMENT $1CORE 3$
            AIDS(0)=777777777777K
            A(CONPNT+CCNT)=777777777777K
            A(CONPNT(1)+CCNT)=777777777777K
            P'S CCNT
            PRINT OCTAL RESULTS SCOPB,SCOPB(1)
            NOCNT=0
            REWIND TAPE FIVE
            EXECUTE SETEOF.(NASTY)
            EXECUTE SETERR.(NASTY)
            T'H QQQ50, FOR QQ=0,1, QQ.GE. CCNT
            A(GRPNT+QQ)=A(IPPNT+QQ)
            A(GRPNT(1)+QQ)=A(IPPNT(1)+QQ)
QQQ50       PRINT OCTAL RESULTS A(5600+QQ),A(6000+QQ)
           RREMOVE ANY DESIRED RESULTS WHICH ARE INPUT PARAMETERS
            T'H KTCHIP, FOR J=0,1, J .GE. CCNT
            MADBUG=(A(IPPNT+J).A.A(DRPNT+J)).FPAR.(A(IPPNT(1)+J).A.A(
           1          DRPNT(1)+J))
            W'R MADBUG
           RDESIRED RESULTS FOUND ON INPUT PARAMETER LIST
            T'H REDIP, FOR VALUES OF K=0,1
REDIP       A(DRPNT(K)+J)=A(DRPNT(K)+J) .A. (.N. A(IPPNT(K)+J))
            E'L
```

```
KTCHIP      CONTINUE
            EXECUTE SUBSPT.
            P'T $H*0TIME TRAP SET FOR* I4,H* SEC.**$,MAXTIM
            TIMTRP.(1,60*MAXTIM,TRAP)
            RAND=0.
            SOLCNT=0
            LLINE=-1
            DRSW=0B
            SOLSW=0B
            T'H SETUP,FOR I=0,1, I .G. CCNT-1
SETUP       LTOR( A(LRPNT(1)+I) ) = I
           RWRITE CURRENT SOLUTION COUNT AND DESIRED RESULT MATRIX
RELOOP      WRITE BINARY TAPE FIVE,SOLCNT,CCNT,A(DRPNT)...A(DRPNT+CCNT-1)
           1    ,A(DRPNT(1))...A(DRPNT(1)+CCNT-1),A(GRPNT)...A(GRPNT+CCNT
           2    -1),A(GRPNT(1))...A(GRPNT(1)+CCNT-1),NOCNT
            T'O LOOPDR
           RCHOOSE A CONNECTION LINE WITH DESIRED RESULTS
START       DRSW=0B
            SOLSW=0B
            T'H LOOPDR, FOR LLINE=0,1, LLINE .G. CCNT-1
HUNTDR      RIDLIN=A(LRPNT+LLINE)
            MADBUG=A(DRPNT+RIDLIN).FPAR.A(DRPNT(1)+RIDLIN)
            W'R MADBUG,T'O GOTDR
LOOPDR      CONTINUE
            W'R .NOT. DRSW. T'O SOLVED
            W'R SOLSW, T'O START
           RNO POSSIBLE SOLUTION EXISTS DOWN THIS PATH - BACK UP
RESET       END OF FILE TAPE FIVE
            REWIND TAPE FIVE
           RRANDOMLY DECIDE WHERE TO RESTART
            I=SOLCNT*RANDOM.(RAND)
            LLINE=CCNT*RANDOM.(RAND)
            P'T FORM1, I,LLINE
            T'H FRESH, FOR J=0,1, J .G. I
FRESH       READ BINARY TAPE FIVE,SOLCNT,CCNT,A(DRPNT)...A(DRPNT+CCNT-1),
           1                          A(DRPNT(1))...A(DRPNT(1)+CCNT-1)
           2   ,A(GRPNT)...A(GRPNT+CCNT-1),A(GRPNT(1))...A(GRPNT(1)+CCNT
           3     -1),NOCNT
            SOLSW=1B
            T'O HUNTDR
           RDESIRED RESULTS ON RIDLIN TO BE ELIMINATED
GOTDR       DRSW=1B
            P'T $H*-ATTEMPTING TO REMOVE DESIRED RESULTS ON LINE*,I5*$,
           1              RIDLIN
            AIDCNT=1
            MBECNT=0
            LINE=LLINE
            LINE(1)=LTOR(A(LRPNT+LINE))
            MAXWT=0.
           RGATHER ALL COLLECTIONS WHICH REDUCE THE DESIRED RESULTS.
            T'H GATHER, FOR VALUES OF SIDE=0,1
            CONETY=A(CONPNT(SIDE)+RIDLIN)
            ELPOS=.ELPOS. CONETY
            PELBAS= 5*ELPOS
            ATPOS= .ATPOS. CONETY
            EIDPOS=.EIDPOS. CONETY
           RBUILD A TABLE POINTING FROM ATTACHMENTS TO CONNECTION LINES
            T'H ATFND1, FOR I=0,1, I .GE. A(PELPNT+PELBAS+2)
ATFND1      ATINFO(I,SIDE)=$ $
```

```
          W'R .ANEG. CONETY
          J=RIDLIN
          XZ=ATPOS
          EXECUTE AIDBLD.(SIDE)
          E'L
          COMP=A(LRPNT(2+SIDE)+LINE(SIDE))
          W'R .ANEG. COMP
          TEST=.ABS. COMP
          O'E
          TEST=A(LRPNT(3-SIDE)+COMP)
          T'H ATFND3, FOR I=COMP,1,A(LRPNT(3-SIDE)+I) .NID. TEST
          J=A(LRPNT(1-SIDE)+I)
          XZ=.ATPOS. A(CONPNT(1-SIDE)+J)
          W'R .ANEG. A(CONPNT(1-SIDE)+J)
          W'R ATINFO(XZ,SIDE) .E. $ $
          EXECUTE AIDBLD.(1-SIDE)
          E'L
          O'E
          W'R .ANEG. A(CONPNT(SIDE)+J)
          EXECUTE AIDBLD.(SIDE)
          ATINFO(XZ,SIDE)= .ABS. ATINFO(XZ,SIDE)
          O'E
          ATINFO(XZ,SIDE)=J
          E'L
ATFND3    E'L
          E'L
          T'H ATFND2, FOR I=TEST,1,A(LRPNT(2+SIDE)+I) .NID. COMP
          J=A(LRPNT(SIDE)+I)
          XZ=.ATPOS. A(CONPNT(SIDE)+J)
          W'R .ANEG. A(CONPNT(SIDE)+J)
          W'R ATINFO(XZ,SIDE) .E. $ $
          EXECUTE AIDBLD.(SIDE)
          E'L
          O'E
          W'R .ANEG. A(CONPNT(1-SIDE)+J)
          EXECUTE AIDBLD.(1-SIDE)
          ATINFO(XZ,SIDE)= .ABS. ATINFO(XZ,SIDE)
          O'E
          ATINFO(XZ,SIDE)=J
          E'L
ATFND2    E'L
          T'H QQQ1, FOR QQ=0,1, QQ .GE. A(PELBAS+PELPNT+2)
          W'R ((.DECR. ATINFO(QQ,SIDE)) .NE. 0) .AND. (ATINFO(QQ,SIDE)
         1        .NE. $ $ )
          EXECUTE BPSPRD.(ATINFO(QQ,SIDE))
              PRINT OCTAL RESULTS ATINFO(QQ,SIDE)
QQQ1      E'L
              PRINT OCTAL RESULTS AIDS...AIDS(AIDCNT-1)
          T'H GATHER, FOR COLPAS=0,1, COLPAS .GE. A(PELPNT+PELBAS+4)
          COLBAS=A(PELPNT+PELBAS+3)+COLPAS*A(PELPNT+PELBAS+2)*4
         RTEST TO SEE IF THE COLLECTION REMOVES ANY BITS ON THE LINE
          MADBUG=(A(DRPNT+RIDLIN).A.B(COLBAS+4*ATPOS+2)).FPAR.(A(DRPNT
         1   (1)+RIDLIN).A.B(COLBAS+4*ATPOS+3))
          W'R MADBUG
              PRINT OCTAL RESULTS  B(COLBAS+4*I)...B(COLBAS+4*I+3)
         RTHIS COLLECTION DOES REMOVE BITS FROM THE LINE.
         RNOW DETERMINE A WEIGHT FOR THE COLLECTION
          IPCNT=0.
          IPHERE=0
```

```
          DRCNT=0.
          IN34=0B
          ESTNOK=0B
          BITS=0
          BITS(1)=0
          BITS(2)=0
          BITS(3)=0
          T'H ADDUP, FOR I=0,1, I .GE. A(PELPNT+PELBAS+2)
          WTOUT=0B
          W'R ATINFO(I,SIDE) .E. $ $, WTOUT=1B
          NOPAR=(.NOT.(B(COLBAS+4*I).FPAR.B(COLBAS+4*I+1))).AND.(.NOT.(
         1     B(COLBAS+4*I+2).FPAR.B(COLBAS+4*I+3)))
          W'R NOPAR .AND. IFBIT.(B(COLBAS+4*I+3),35) .AND. .NOT. WTOUT
         1           , T'O GATHER
          W'R WTOUT .AND. .NOT. NOPAR, T'O GATHER
          W'R NOPAR .OR. WTOUT, T'O ADDUP
          T'H ESTPEN, FOR QQ = 0,1, QQ .G. 3
ESTPEN    BITS(QQ) = BITS(QQ) .V. B(COLBAS+4*I+QQ)
          W'R IFBIT.(B(COLBAS+4*I+1),35)
          W'R .ANEG. ATINFO(I,SIDE)
         RATTACHMENT IDENTIFIER AND SUMMATION COLLECTION.
SUMUP     CONTINUE
          W'R ATPOS .NE. I
          W'R (B(COLBAS+4*I+2).A.(.N.SCOPB)).FPAR.(B(COLBAS+4*I+3).A.
         1        (.N.SCOPB(1))), T'O GATHER
          IPCNT=IPCNT+((.N.A(IPPNT+.ADR.ATINFO(I,SIDE))).A.B(COLBAS+4*I
         1        ).A.(.N.SCOPB)) .COUNT. ((.N.A(IPPNT(1)+.ADR. ATINFO
         2        (I,SIDE))).A.B(COLBAS+4*I+1).A.(.N.SCOPB(1)))
          E'L
          CONETY=COLBAS.IND. RIDLIN
CKNOTB    T'H CKNOTB, FOR XI=0,1,(XI .GE. NOCNT) .OR. (CONETY .E.
         1        NOTAB(XI))
          W'R XI .L. NOCNT, T'O GATHER
         RCOUNT THE BROAD-SCOPE PARAMETER BITS.
          IPCNT=IPCNT+((.N.A(IPPNT+.ADR.ATINFO(I,SIDE))).A.B(COLBAS+
         1        4*I).A.SCOPB) .COUNT. ((.N. A(IPPNT(1)+.ADR. ATINFO
         2        (I,SIDE))).A. B(COLBAS+4*I+1) .A. SCOPB(1))
         RCOUNT THE NARROW-SCOPE PARAMETER BITS.
          T'H SUM, FOR XI=.DECR.ATINFO(I,SIDE),-XI+.DECR.AIDS(XI),.ANEG
         1        . AIDS(XI)
SUM       IPCNT=IPCNT+((.N.A(IPPNT+AIDS(XI))).A.B(COLBAS+4*I).A.(.N.
         1        SCOPB)) .COUNT. ((.N.A(IPPNT(1)+AIDS(XI))).A.B(COLBAS
         2        +4*I+1).A.(.N. SCOPB(1)))
          T'O SUM2
          O'E
         RSUMMATION COLLECTION BUT NO ATTACHMENT IDENTIFIER.
          T'O SUMUP
          E'L
          O'E
          W'R .ANEG. ATINFO(I,SIDE)
         RATTACHMENT IDENTIFIERS BUT NO SUMMATION COLLECTION.
         R***  CAN GET BURNED BY NARROW-SCOPE PARAMETERS  ***
          T'O NOATBR
          C'E
         RNO ATTACHMENT IDENTIFIERS AND NO SUMMATION COLLECTION
NOATBR    CONTINUE
          IPCNT=IPCNT+((.N.A(IPPNT+.ADR.ATINFO(I,SIDE))).A.B(COLBAS+
         1        4*I)) .COUNT. ((.N. A(IPPNT(1)+.ADR.ATINFO(I,SIDE)))
         2        .A. B(COLBAS+4*I+1))
```

```
SUM2        CONTINUE
            DRCNT=DRCNT+(A(DRPNT+.ADR.ATINFO(I,SIDE)).A.B(COLBAS+4*I+2))
           1         .COUNT. (A(DRPNT(1)+.ADR.ATINFO(I,SIDE)).A.B(COLBAS+4
           2         *I+3))
            IN34=IN34 .OR. IFBIT.(B(COLBAS+4*I+3),34)
            ESTNOK=ESTNOK.OR.((B(COLBAS+4*I+2).A.(.N.A(GRPNT+.ADR.
           1         ATINFO(I,SIDE)))).FPAR.(B(COLBAS+4*I+3).A.(.N.
           1         A(GRPNT(1)+.ADR.ATINFO(I,SIDE)))))
            IPHERE=IPHERE+B(COLBAS+4*I) .COUNT. B(COLBAS+4*I+1)
            E'L
            END OF CONDITIONAL
ADDUP       CONTINUE
                P'S  IPCNT,IPHERE,DRCNT
            SOLSW=1B
            W'R IPCNT .NE. 0.
            QQ=(BITS.A.BITS(2)).COUNT.(BITS(1).A.BITS(3))
            IPCNT = IPCNT + 4*QQ
            E'L
            W'R IPHERE .E. 0
           RSTATEMENT COLLECTION IS FOR COMPUTE OR ESTIMATE
            W'R IN34
           RTHIS IS A COMPUTE STATEMENT - GIVE IT A LARGE WEIGHT
GOODUN      CONTINUE
            WHGHT=100.*DRCNT
            O'E
           RTHIS IS AN ESTIMATE STATEMENT - GIVE IT A LOW WEIGHT
            W'R ESTNOK, T'O GATHER
            WHGHT=DRCNT/PARCNT
            E'L
            O'E
           RTHIS IS A NORMAL STATEMENT - GIVE IT A REGULAR WEIGHT
            W'R IPCNT .E. 0. , T'O GOODUN
            WHGHT=DRCNT/IPCNT
            E'L
           RNOW SAVE THE WEIGHTS, ETC.
            MAXWT=MAXWT+WHGHT
            CHOICE(MBECNT)=MAXWT
            CHINFO(MBECNT,1)=SIDE
            CHINFO(MBECNT,2)=COLBAS
            CHINFO(MBECNT,3)=PELBAS
            CHINFO(MBECNT,4)=ELPOS
            CHINFO(MBECNT,5)=COLPAS
            CHINFO(MBECNT,6)=EIDPOS
            MBECNT=MBECNT+1
            P'T $S11,H*SIDE*I2,H*, ELEMENT *C6,H*,  COLLECTION *I3,H*,  W
           1EIGHT *F9.3,S10,I3*$,  SIDE,A(PELPNT+PELBAS),COLPAS+1,WHGHT,
           2         MBECNT
            E'L
GATHER      CONTINUE
            W'R MBECNT .E. 0
            P'T $HZ0*****  NO BITS CAN BE REMOVED FROM THIS LINE.Z*$
            W'R ((A(DRPNT+RIDLIN).A.(.N.SCOPB)).FPAR.(A(DRPNT(1)+RIDLIN)
           1         .A.(.N.SCOPB(1))))
            P'T $HZ *****  NARROW SCOPE PARAMETERS CANNOT BE REMOVED.Z*$
            T'O RESET
            C'E
            T'O LOOPDR
            E'L
            E'L
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```
          RNOW CHOOSE A COLLECTION
           WHGHT=MAXWT*RANDOM.(RAND)
ATTACK     T'H ATTACK, FOR I=0,1, CHOICE(I) .GE. WHGHT
          RWE HAVE DECIDED TO USE THE I'TH STATEMENT COLLECTION
           P'T $H*OWE HAVE ELECTED TO USE CHOICE*,I3,H* FROM THE ABOVE.*
          1*$,  I+1
          RNOW OUTPUT THE STRING OF INFORMATION FOR CORE 4.
           A(SOLPNT+SOLCNT)= RIDLIN
           T'H PUTWAY, FOR J=1,1, J .G. 3
PUTWAY     A(SOLPNT(J)+SOLCNT)=CHINFO(I,J+3)
           A(SOLPNT(2)+SOLCNT)=A(SOLPNT(2)+SOLCNT)+1
           SIDE=CHINFO(I,1)
           COLBAS=CHINFO(I,2)
           PELBAS=CHINFO(I,3)
           W'R SIDE .E. 1,A(SOLPNT(1)+SOLCNT)=-A(SOLPNT(1)+SOLCNT)
           SOLCNT=SOLCNT+1
          RNOW UPDATE THE DESIRED RESULT BITS
           T'H FIXUP, FOR J=0,1, J .GE. A(PELPNT+PELBAS+2)
           W'R ATINFO(J,SIDE) .E. $ $, T'O FIXUP
           A(DRPNT+.ADR.ATINFO(J,SIDE))=A(DRPNT+.ADR.ATINFO(J,SIDE)).V.
          1         B(COLBAS+4*J)
           A(DRPNT(1)+.ADR.ATINFO(J,SIDE))=A(DRPNT(1)+.ADR.ATINFO(J,SIDE
          1         )).V.B(COLBAS+4*J+1)
           A(DRPNT+.ADR.ATINFO(J,SIDE))=A(DRPNT+.ADR.ATINFO(J,SIDE)).A.
          1         (.N.B(COLBAS+4*J+2))
           A(DRPNT(1)+.ADR.ATINFO(J,SIDE))=A(DRPNT(1)+.ADR.ATINFO(J,SIDE
          1         )).A.(.N.B(COLBAS+4*J+3))
           A(DRPNT+.ADR.ATINFO(J,SIDE))=A(DRPNT+.ADR.ATINFO(J,SIDE)).A.
          1         (.N.A(IPPNT+.ADR.ATINFO(J,SIDE)))
           A(DRPNT(1)+.ADR.ATINFO(J,SIDE))=A(DRPNT(1)+.ADR.ATINFO(J,SIDE
          1         )).A.(.N.A(IPPNT(1)+.ADR.ATINFO(J,SIDE)))
           A(GRPNT+.ADR.ATINFO(J,SIDE))=A(GRPNT+.ADR.ATINFO(J,SIDE)).V.
          1         B(COLBAS+4*J+2)
           A(GRPNT(1)+.ADR.ATINFO(J,SIDE))=A(GRPNT(1)+.ADR.ATINFO(J,SIDE
          1         )).V.B(COLBAS+4*J+3)
           W'R IFBIT.(B(COLBAS+4*J+1),35)
          RSPRAY NARROW-SCOPE DESIRED RESULT BITS FOR SUMMATIONS.
           T'H SUM1, FOR XI=.DECR.ATINFO(J,SIDE),-XI+.DECR.AIDS(XI),
          1         .ANEG. AIDS(XI)
           NOTAB(NOCNT) = COLBAS .IND. AIDS(XI)
           NOCNT=NOCNT+1
           A(DRPNT+AIDS(XI))=A(DRPNT+AIDS(XI)).V.(B(COLBAS+4*J).A.(.N.
          1         SCOPB))
           A(DRPNT(1)+AIDS(XI))=A(DRPNT(1)+AIDS(XI)).V.(B(COLBAS+4*J+1)
          1         .A. (.N. SCOPB(1)))
           A(DRPNT+AIDS(XI))=A(DRPNT+AIDS(XI)).A. (.N.A(IPPNT+AIDS(XI)))
SUM1       A(DRPNT(1)+AIDS(XI))=A(DRPNT(1)+AIDS(XI)).A.(.N.A(IPPNT(1)+AI
          1         DS(XI)))
           E'L
           W'R (.DECR. ATINFO(J,SIDE)) .NE. 0, EXECUTE BPDELT.(ATINFO
          1         (J,SIDE))
FIXUP      CONTINUE
           P'T $S6,H*THE STATUS AS OF SOLUTION LINE*,I3,H* IS AS FOLLOWS
          1 **$, SOLCNT
           EXECUTE SUBSPT.
           T'O RELOOP
NASTY      EXECUTE ERROR.
          RTIME TRAP  -  GO TO NEXT PROBLEM.
TRAP       PRINT COMMENT $O NO SOLUTION FOUND IN THE ALLOTED TIME.$
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          PRINT COMMENT $OPROBLEM STATUS FOLLOWS BELOW.$
          T'H BBB, FOR I=0,1, I .GE. SOLCNT
BBB       P'T FORM3,A(SOLPNT+I),A(SOLPNT(1)+I),A(SOLPNT(2)+I),
         1          A(SOLPNT(3)+I)
          EXECUTE SUBSPT.
          EXECUTE PANEL.
          EXECUTE SDUMP.(A(15999)...TOPCOR)
          EXECUTE SELPGM.(1)
         RSOLUTION FOUND - RESET TIME TRAP AND NOTE TIME
SOLVED    TIME = MAXTIM - RESTIM.(1)/60.
          P'T FORM2, TIME
          PRINT COMMENT $1SOLUTION FOLLOWS ( IN REVERSE ORDER ).$
          T'H AAA, FOR I=0,1, I .GE. SOLCNT
AAA       P'T FORM3, A(SOLPNT+I),A(SOLPNT(1)+I),A(SOLPNT(2)+I),A(SOLPNT
         1(3)+I)
          EXECUTE SEQPGM.
         RFORMAT STRINGS FOR ALL I/O STATEMENTS
          V'S FORM1=$H*0BLIND ALLEY - NEW SOLCNT,LLINE ARE *,2I5*$
          V'S FORM2=$H*0SOLUTION FOUND IN *F6.2,H* SEC.**$
          V'S FORM3=$S1,4I10*$
         RVARIABLE MODE DECLARATIONS
          NORMAL MODE IS INTEGER
          BOOLEAN DRSW,SOLSW,IN34,WTOUT,IFBIT.,NOPAR
          BOOLEAN ESTNOK
          BOOLEAN MADBUG
          BOOLEAN Y4
          FLOATING POINT RANDOM.,RAND,IPCNT,DRCNT,MAXWT,CHOICE
          FLOATING POINT TIME
          FLOATING POINT WHGHT
         RDIMENSIONING AND COMMON ALLOCATIONS
          PROGRAM COMMON INDEX(99),A(15899),B(1999),BROAD(200)
          ERASABLE TOPCOR
          DIMENSION DRPNT(1),LRPNT(3),CONPNT(1),LTOR(399),IPPNT(2),
         1          CHOICE(40),CHINFO((0...40)*6),ATINFO((0...20)*
         2             (0...1)),SOLPNT(3),LINE(1)
          DIMENSION AIDS(40), XLST((0...10)*2)
          DIMENSION BITS(5),SCOPB(1)
          DIMENSION NOTAB(400)
          EQUIVALENCE (A(15600),SOLCNT)
          EQUIVALENCE (A(15842),CCNT)
          EQUIVALENCE (SCOPB,A(15770))
          EQUIVALENCE (PARCNT,A(15603))
          EQUIVALENCE ( MAXTIM,INDEX(99))
          V'S FIVE=9
          V'S DRPNT=10000,10400
          V'S LRPNT=10800,11200,11600,12000
          V'S CONPNT=5600,6000
          V'S IPPNT=9200,9600
          V'S SOLPNT=100,500,900,1300
          V'S PELPNT=8200
          V'S GRPNT=12400,12800
          INTERNAL FUNCTION
          ENTRY TO SUBSPT.
          P'T $1H0,T7,1HL,T13,1HR,T18,2HLR,T24,2HRL,T35,3HIP1,S11,3HIP2
         1S11,3HDR1S11,3HDR2S11,3HGR1S11,3HGR2S14,4HLINE*$
          T'H QQQ10, FOR QQ=0,1, QQ .G. CCNT-1
QQQ10     P'T FORM9,A(LRPNT+QQ),A(LRPNT(1)+QQ),A(LRPNT(2)+QQ),
         1A(LRPNT(3)+QQ),A(IPPNT+QQ),A(IPPNT(1)+QQ),A(DRPNT+QQ),
         2A(DRPNT(1)+QQ),A(GRPNT+QQ),A(GRPNT(1)+QQ),QQ
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          F'N
          V'S FORM9=$S1,4I6,S9,6(K12,S2),I6*$
          E'N
          INTERNAL FUNCTION (XSIDE)
          ENTRY TO AIDBLD.
          ATINFO(XZ,SIDE)= - ( J .IND. AIDCNT)
          XLST(0,1)=J
          XLST(0,2)=XSIDE
          XLPNT=0
          T'H XBATCH, FOR XI=0,1, XI .G. XLPNT
          CONETY=A(CONPNT(XLST(XI,2))+XLST(XI,1))
          XAT= .ATPOS. CONETY
XSRCH     T'H XSRCH, FOR XJ=0,1, A(LRPNT(XLST(XI,2))+XJ) .E. XLST(XI,1)
          XCOMP=A(LRPNT(2+XLST(XI,2))+XJ)
          W'R .ANEG. XCOMP
          XTEST=.ABS. XCOMP
          C'E
          XTEST=A(LRPNT(3-XLST(XI,2))+XCOMP)
          T'H XFND3, FOR TI=XCOMP,1,A(LRPNT(3-XLST(XI,2))+TI) .NID.
         1        XTEST
          J=A(LRPNT(1-XLST(XI,2))+TI)
          W'R XAT .E. ( .ATPOS. A(CONPNT(1-XLST(XI,2))+J))
XCHK      T'H XCHK, FOR TJ=0,1, TJ .G. XLPNT .OR. J .E. XLST(TJ,1)
          W'R TJ .E. 0 .AND. XI .E. 0, T'O OK1
          W'R TJ .G. XLPNT
          AIDS(AIDCNT)= J .IND. (AIDCNT+1)
          W'R XI .NE. 0, AIDS(AIDCNT)=-AIDS(AIDCNT)
          AIDCNT=AIDCNT+1
OK1       CONTINUE
          W'R .ANEG. A(CONPNT(XLST(XI,2))+J)
          XLPNT=XLPNT+1
          XLST(XLPNT,1)=J
          XLST(XLPNT,2)=XLST(XI,2)
          E'L
          E'L
XFND3     E'L
          E'L
          T'H XFND2, FOR TI=XTEST,1,A(LRPNT(2+XLST(XI,2))+TI) .NID.
         1        XCOMP
          J=A(LRPNT(XLST(XI,2))+TI)
          W'R XAT .E. (.ATPOS. A(CONPNT(XLST(XI,2))+J))
XCHK2     T'H XCHK2, FOR TJ=0,1, TJ .G. XLPNT .OR. J .E. XLST(TJ,1)
          W'R TJ .E. 0 .AND. XI .E. 0, T'O OK2
          W'R TJ .G. XLPNT
          AIDS(AIDCNT)= J .IND. (AIDCNT+1)
          W'R XI .NE. 0, AIDS(AIDCNT)=-AIDS(AIDCNT)
          AIDCNT=AIDCNT+1
OK2       CONTINUE
          W'R .ANEG. A(CONPNT(1-XLST(XI,2))+J)
          XLPNT=XLPNT+1
          XLST(XLPNT,1)=J
          XLST(XLPNT,2)=1-XLST(XI,2)
          E'L
          E'L
XFND2     E'L
XBATCH    CONTINUE
          AIDS(AIDCNT)= 777777777777K
          AIDCNT=AIDCNT+1
          F'N
```

```
            E'N
            INTERNAL FUNCTION (ARG)
            ENTRY TO BPSPRD.
            Y4=1B
            T'H Y1, FOR VALUES OF XI=0,1
            BITS(XI)=A(IPPNT(XI)+.ADR. ARG)
            BITS(XI+4)=A(GRPNT(XI)+.ADR.ARG)
Y1          BITS(XI+2)=A(DRPNT(XI)+.ADR. ARG)
            T'H Y2, FOR XJ=.DECR. ARG, -XJ+.DECR. AIDS(XJ), AIDS(XJ) .E.
           1        777777777777K
            T'H Y2, FOR VALUES OF XI=0,1
            BITS(XI)=A(IPPNT(XI)+.ADR.AIDS(XJ)).V.BITS(XI)
            BITS(XI+4)=A(GRPNT(XI)+.ADR.AIDS(XJ)).V.BITS(XI+4)
Y2          BITS(XI+2)=A(DRPNT(XI)+.ADR.AIDS(XJ)).V.BITS(XI+2)
            T'H Y3, FOR VALUES OF XI=0,1
            A(IPPNT(XI)+.ADR.ARG)=(BITS(XI).A.SCOPB(XI)).V.A(IPPNT(XI)+
           1        .ADR. ARG)
            A(GRPNT(XI)+.ADR.ARG)=(BITS(XI+4).A.SCOPB(XI)).V.A(GRPNT(XI)+
           1        .ADR. ARG)
Y3          A(DRPNT(XI)+.ADR.ARG)=((BITS(XI).A.SCOPB(XI)).V.A(DRPNT(XI)+
           1        .ADR.ARG)).A.(.N.A(IPPNT(XI)+.ADR.ARG))
            ENTRY TO BPDELT.
            T'H T1, FOR XJ= .DECR. ARG, -XJ+.DECR. AIDS(XJ), AIDS(XJ) .E.
           1        777777777777K
            T'H T1, FOR VALUES OF XI=0,1
            W'R Y4
            A(IPPNT(XI)+.ADR.AIDS(XJ))=A(IPPNT(XI)+.ADR.AIDS(XJ)).V.(A(
           1        IPPNT(XI)+.ADR.ARG).A.SCOPB(XI))
            E'L
            A(GRPNT(XI)+.ADR.AIDS(XJ))=A(GRPNT(XI)+.ADR.AIDS(XJ)).V.(SCOP
           1        B(XI).A.A(GRPNT(XI)+.ADR.ARG))
T1          A(DRPNT(XI)+.ADR.AIDS(XJ))=(A(DRPNT(XI)+.ADR.AIDS(XJ)).V.SCOP
           1        B(XI)).A.((.N.SCOPB(XI)).V.A(DRPNT(XI)+.ADR.ARG)).A.
           2        (.N.A(IPPNT(XI)+.ADR.AIDS(XJ)))
            Y4=0B
            F'N
            E'N
            END OF PROGRAM                                                *
$ASSEMBLE,PUNCH OBJECT                                  IFBIT000IFBIT000
***     SUBROUTINE IFBIT.
***     A TYPICAL CALL FROM MAD WOULD BE AS FOLLOWS
***     WHENEVER IFBIT.(A,N)
***     IFBIT. RETURNS 1B IF A HAS A BIT IN LOCATION N.
***     OTHERWISE 0B IS RETURNED.
        ENTRY   IFBIT
IFBIT   CLA*    2,4
        STA     SHIFT
        CAL     =K4K11
SHIFT   ARS     **
        ANA*    1,4
        TRA     3,4
        END                                                               *
```

```
$ASSEMBLE,PUNCH OBJECT                                          RESTIMOORESTIMOO
***     SUBROUTINE RESTIM.
***     A TYPICAL MAD CALLING SEQUENCE WOULD BE AS FOLLOWS
***     TIME=TIMAX-RESTIM.(CELL)/60.
***     THIS SUBROUTINE WILL RESET TIME TRAP 'CELL', AND RETURN THE
***     TIME DURATION THAT REMAINED AS A FULL WORD INTEGER, IN 60TH'S OF
***     A SECOND.
        ENTRY   RESTIM
RESTIM  CLA*    1,4
        PAX     0,2
        SXD     CELL2,2
        SXD     CELL3,2
        SXA     A,4
        CLA     1,4
        STA     CELL1
        CALL    ITMLFT                  GET TIME REMAINING.
CELL1   PAR     **
        STO     SVTIM
        CALL    SETTIM                  RESTORE TIME TRAP
CELL2   BLK     =0,,**
        CALL    SETTRP                  CLEAN UP TRAP CELL
CELL3   BLK     =0,,**
A       AXT     **,4
        CLA     SVTIM
        TRA     2,4
SVTIM   NOP     **                      DUMMY STORAGE BOX
        END                                                             *
```

```
$ASSEMBLE,PUNCH OBJECT                                          TIMTRP00TIMTRP00
***     SUBROUTINE TIMTRP.
***     A TYPICAL MAD CALLING SEQUENCE WOULD BE AS FOLLOWS
***     EXECUTE TIMTRP.(CELL,TIME,WHERETO)
***     CELL IS THE LOGICAL TIME CELL NUMBER.
***     TIME IS THE DESIRED TIME DURATION IN 60TH'S OF SECONDS.
***     WHERETO IS THE STATEMENT LABEL TO WHICH CONTROL ISTRANSFERRED ON
***     A TRAP.
        ENTRY   TIMTRP
TIMTRP  CLA*    1,4
        PAX     0,2
        SXD     TIME,2                  INIT TIMER NUMBER
        SXD     WHTO,2
        CLA     2,4
        STA     TIME                    INIT TIME INTERVAL
        CLA     3,4
        STA     WHTO                    INIT TRAP ADDRESS
        SXA     A,4
        CALL    SETTIM
TIME    BLK     **,,**
        CALL    SETTRP
WHTO    BLK     **,,**
A       AXT     **,4
        TRA     4,4                     RETURN TO MAIN
        END                                                             *
```

```
$ASSEMBLE,PUNCH OBJECT                                                  SYS/ER00
        ENTRY   SYSTEM,ERROR
SYSTEM  NOP
ERROR   PXA     0,4
        PAC     0,4
        SXA     IN,4
        PRINT   FORMAT,IN,0
        CALL    PANEL
       8CALL    SDUMP,10000,,,,77777
        CALL    SELRCD
        BLK     1,,2
IN      PZE
FORMAT  BCI     *,H*6SYSTEM/ERROR CALLED FROM  *,K5*
        END                                                                     *
```

```
$COMPILE MAD, PRINT OBJECT, PUNCH OBJECT                                CORE4000
          R'N
          P'R QQ(100)
          D'N ELMID(QQ),ELM(QQ),LINENO(QQ),COLLNO(QQ)
          EQUIVALENCE (A(15603),PARCNT),(A(15602),TELCNT),
         1            (A(15601),PELCNT),(A(15851),NOELMS),
         2            (A(100  ),LINENO),(A(500  ),ELM),
         3            (A(900  ),COLLNO),(A(1300),ELMID),
         4            (A(15600),NOSOL)
          EQUIVALENCE (PELT,A(8200)),(CONL,A(5600)),(CONR,A(6000))
          EQUIVALENCE(A(8600),ATS)
          D'N ATS(100)
          D'N PELT(300),CONL(400),CONR(400),ELMLST(100),STMNT(100)
          DEFINE UNARY OPERATOR .M.,PRECEDENCE SAME AS .E.
          M'E 2 = .M.1
      CLA     B
      TMI     LOC+3
      PXA     ,0
      TRA     LOC+2
      CLA     =1
      OUT     AC
      END
          EQUIVALENCE (NOELM,NOELMS)
          DEFINE UNARY OPERATOR .STZ., PRECEDENCE SAME AS =
          M'E .STZ. 1
      STZ     B
      OUT     Z
      END
          M'E .STZ. 2, S'S .STZ.1
          N'R
          B'N TWICE
          V'S ONE = 1
          V'S TWO = 2
          V'S FOUR = 4
          V'S ELTAPE = $ELTAPE$
          V'S PROLOG = $PROLOG$
          P'N A(15999),C(1999),BROAD(200)
          EQUIVALENCE (C,B)
          D'N B(7599)
          V'S MASKED = 777K
          V'S ZICK = $H90***** CORE4 -- CHECK NO. -915,5H******$
          V'S TSTFOR = 0B


          PRINT COMMENT $1***** CORE4 HAS ARRIVED. *****$
          (I=0,1,I.GE.NO SOL. ELM(I)=ELM(I).V.(ELMID(I).LS.9).V.(COLLNO
         1(I).LS.18))
          P'T $4(S10,K12,S2,I6)*$,(I=0,1,I.GE.NOSOL,ELM(I),LINENO(I))
          PRINT BCD RESULTS ATS...ATS(100)
          P'T$H90***** PELT TABLE*****9*$
          PRINT OCTAL RESULTS PELT...PELT(NOELMS*5)
          TWICE = 1B
          .STZ. COUNT
AGAIN     REWIND TAPE FOUR
          W'R TSTFOR, P'T ZICK, 1
          SETEOF.(C1)
AGAIN2    READ BINARY TAPE FOUR,WORD
          W'R TSTFOR, P'T ZICK, 2
```

```
          W'R WORD .E. ELTAPE
          W'R TSTFOR, P'T ZICK, 3
          READ BINARY TAPE FOUR,PELCNT,TELCNT,PARCNT
          NOELMS = PELCNT + TELCNT
          W'R TSTFOR, PRINT BCD RESULTS PELCNT,PARCNT,TELCNT,NOELMS
          SKIP.(TWO,0,FOUR)
          T'O READY
          E'L
          W'R TSTFOR, P'T ZICK, 4
          W'R TWICE
          .STZ. TWICE
          T'O AGAIN2
          E'L
C1        TIME = -1
          W'R TSTFOR, P'T ZICK, 5
          SETEOF.(C2)
          TWICE = 1B
          SKIP.(ONE,0,FOUR)
C         READ BINARY TAPE FOUR, WORD
          W'R TSTFOR, P'T ZICK, 6
          W'R WORD .E. PROLOG
          W'R TSTFOR, P'T ZICK, 7
          SKIP.(ONE,0,FOUR)
          T'O READY
          E'L
C(1)      COUNT = COUNT + 1
          W'R COUNT .L. 10, T'O AGAIN
          PRINT COMMENT $6***** TAPE FOUR COULD NOT BE POSITIONED CORRE
         1CTLY FOR READING STATEMENT COLLECTIONS.$
          SEQPGM.
C2        TIME = TIME + 1
          W'R TSTFOR, P'T ZICK, 8
          T'O C(TIME)
READY
          W'R TSTFOR, P'T ZICK, 9
          .STZ. CNT
          .STZ. STMNT
          .STZ.COLCNT
          .STZ. ELMLST
          .STZ. SCNT
          .STZ.SZ
UPHS      T'H SETABL, FOR ELCNT = 0,1,ELCNT .GE.NOELMS
          SETEOF.(BAD)
          READ BINARY TAPE FOUR, WORDS, NOATS
          W'R TSTFOR, PRINT BCD RESULTS WORDS,NOATS,PELT(ELCNT*5),ELCNT
          W'R WORDS .NE. PELT(ELCNT*5)
          SZ = 1
          E'L
          SKIP.(1,1,FOUR)
MUCH
          SETEOF.(NXTONE)
          READ BINARY TAPE FOUR, NOCRDS,NOCOL
          W'R TSTFOR, PRINT BCD RESULTS NOCRDS, NOCOL
          SCNT = SCNT + 1
          SETEOF.(BAD)
          W'R NOCRDS .G. 0
          START = COLCNT
          COLCNT = COLCNT + NOCRDS * 12
          READ BINARY TAPE FOUR, B(START)...B(COLCNT-1)
```

```
            W'R TSTFOR,
           1P'T $1H 12C6*$,(I=START,12,I.GE.COLCNT,B(I)...B(I+11))
            E'L
            STMNT(SCNT) = COLCNT
            W'R TSTFOR, P'T ZICK, 10
            T'O MUCH
NXTONE      CNT = CNT + 1
            ELMLST(CNT) = SCNT
SETABL
            W'R TSTFOR, P'T ZICK, 11
            W'R SZ .G. 0, T'O CHECK
DONCHK
            W'R TSTFOR
            PRINT FORMAT $8(S5,I10)*$,(I=0,1,I.G.NOELM,ELMLST(I)),(I=0,1,
           1I.G.ELMLST(NOELM),STMNT(I))
            E'L
            T'H GENALL, FOR I = NOSOL-1,-1,I .L. 0
            (JKQ=NOSOL-1,-1,(LINENO(JKQ).E.LINENO(I).AND.ELM(JKQ).E.
           1ELM(I)).OR.(JKQ.LE.I))
            W'R JKQ .LE. I
            J = ELMLST(ELM(I) .A. MASKED) + COLLNO(I)
            P'T $H91HERE WE GO LOOP-DE-LOOP.9*$
            SSCAN.(STMNT(J),STMNT(J-1),ELM(I),LINENO(I))
            O'E
            PRINT COMMENT $0 BANG, BANG, BANG ... YOU'R DEAD. (STATEMENT
           1COLLECTION GENERATION DELETED)$
            E'L
GENALL
            W'R TSTFOR, P'T ZICK, 13
            PUNCH FORMAT $T80,1H**$
            SEQPGM.
BAD         PRINT COMMENT $0***** UPHS......$
            SZ = 2
            W'R ELCNT .E. 0, T'O UPHS
            T'O SETABL
CHECK       P'T $1H 12C6*$,A(5600)...A(STMNT(SCNT))
            T'O DONCHK
            E'M
$ASSEMBLE, PRINT OBJECT, PUNCH OBJECT                                GETBRD000
       ENTRY   GETBRD
*************************************************************************
***    ROUTINE TO SELECT A BIT BETWEEN 1 AND 36 * NUMBER OF BROAD-    ****
***    SCOPE BIT WORDS -----    TEST AND RETURN A 1B IF ON, A 0B IF    ****
***    OFF                                                            ****
*************************************************************************
GETBRD LDQ*     1,4       BIT NUMBER
       DVP      THREE6    DETERMINE WORD BIT IS IN
       XCA
       PAX      ,1
       XCA
       MPY      THREE6
       ADD      =1
       SUB      1,4       DETERMINE BIT TO BE EXAMINED
       STA      *+4
       CLA      2,4
       STA      *+1
       CAL*     **,1
       ALS      **        MOVE BIT TO END OF AC
       TMI      *+3       IS BIT ON .....
```

```
        TRA     *+3
        CLA     =1          YES ..
        TRA     1,4
        PXA     ,0          NO
        TRA     1,4
THREE6  DEC     36
        END                                                    *
```

```
$ASSEMBLE,PRINT OBJECT,PUNCH OBJECT                                PMBCDN000
        ENTRY   SET
ATS     MACRO   /LFS/TAG,A,B
TAG     CAL     A,4
        IRP     B
        STA     B
        IRP
        ENDM
SET     ATS     1(PSTO+1,BCDNUM,MOVE-2,MOVE+5,ZQ-2)
        ATS     2,BCDNUM+2
        ATS     3(ZQ-5,AA+2,ZERO)
        ATS     4(BCDNUM-3,ZQ1-2,ZQ1,ZQ1+3,ZQ-4)
        ADD     =2
        STA     ZQ1+1
        STA     ZQ1+2
        TRA     1,4
        ENTRY   PSTO,MOVE,BCDNUM
PSTO    LDQ*    1,4
        LXA     J,1
        AXT     3,2
        TRA     *+2
-3      LGL     6
-2      TXI     *+1,1,1
-1      STQ     OUTPUT,1
        TIX     *-3,2,1
        TRA     *+2
BCDNUM  LXA     J,1
        AXT     3,2
        LDQ     QQ
        PXA     ,0
        TRA     *+2
-6      LDQ     ZQ
-5      TXI     *+1,1,1
-4      DVP     =10
-3      STQ     ZQ
        LGR     6
-1      STQ     OUTPUT,1
        TIX     *-6,2,1
ZQ1     CLA     OUTPUT,1
        LDQ     OUTPUT-2,1
        STO     OUTPUT-2,1
        STQ     OUTPUT,1
        SXA     J,1
        TRA     1,4
MOVE    CLA*    1,4
        PAX     ,2
        CLA*    2,4
        PAX     ,1
        SXD     *+3,1
        LXA     J,1
-5      TXI     *+1,2,1
-4      TXH     *+5,2,**
-3      TXI     *+1,1,1
-2      CLA     CARD,2
-1      STO     OUTPUT,1
        TRA     *-5
        SXA     J,1
        TRA     1,4
ZQ      PZE
```

```
J       PGMCCM  1000
CARD    EQU     J-1
OUTPUT  EQU     J-73
QQ      EQU     J-74
        ENTRY   FIND,FIND1,FIND2,FIND3
FIND    CLA*    5,4         STARTING SUB VALUE
        STA     FIND3
        CLA*    4,4         LAST POSITION TO BE LOOKED AT
        ALS     18
        STD     DONE
FIND1   CLA     3,4         ADD OF VEC TO SAVE SUBS IN
        STA     VEC
        STA     SAVE
        AXT     0,2
FIND2   CLA     2,4         ADD OF VEC TO BE SEARCHED
        STA     ZERO
FIND3   AXT     **,1
        CAL*    1,4         WORD SOUGHT
        SLW     ZQ
ZERO    LAS     **,1
        TXI     *+3,1,1
        TXI     SAVE-1,2,1
        TXI     *+1,1,1
DONE    TXL     ZERO,1,**       IF NOT DONE,TRY NEXT ONE
VEC     SXA     **,2            ZERO LOC HOLDS LENGTH OF VECTOR
        TRA     1,4
        PXA     ,1
SAVE    STO     **,2
        CAL     ZQ
        TXI     DONE,1,1
        ENTRY   WORD
WORD    CLA*    2,4             SUBSCRIPT OF RIGHT END
        PAX     ,1
        TXI     *+1,1,-1
        SXD     AA,1
        CLA*    1,4             SUBSCRIPT OF LEFT END
        PAX     ,1
        AXT     36,2
        REM
        TXI     *+1,1,1
AA      TXH     OUT,1,**
        XCL
        CAL     CARD,1
        LAS     BLANK
        TRA     *+2
        TRA     AA,1,1
        XCL
        LGL     6
NEXT    TIX     AA-1,2,6
        TRA     QUIT
OUT     SXA     *+2,2
        LDQ     BLANK
        LGL     **
QUIT    XCL
        XCA
        TRA     1,4
BLANK   BCD 1
        END                                                     *
```

```
$     COMPILE MAD,PRINTOBJECT,PUNCHOBJECT,EXECUTE                    SSCAN000
      EXTERNAL FUNCTION (BOTTOM,TOP,EL,NOLINE)
      R'N
      E'O SSCAN.
      N'R
      P'R AQ(500)
      P'R BQ(299)
      P'R CQ(69)
      P'R EQ(7599)
      PARAMETER MQ(100)
      PARAMETER NQ(199)
      P'N A(15999),C(1999),BROAD(200)
      EQUIVALENCE (C,B)
      D'N B(7599)
      D'N PLACE(2),SAVE(MQ),SLIST(NQ),ATS(NQ)
      DIMENSION AREA(AQ),PELT(BQ),ZPAR(CQ)
      D'N CARD(71)
      EQUIVALENCE (A(8600),ATS),(A(8200),PELT),(A(15700),FPAR),
     1 (A(15603),PARCNT),(A(15772),ZPAR),(FPAR(70),BWORDS),
     2 (A(5600),CONL),(A(6000),CONR),(A(15842),ELMCNT)
      EQUIVALENCE (A(15600),NOSOL)
      EQUIVALENCE (A(15842),CCNT)
      EQUIVALENCE (PLACE,LP),(PLACE(1),RP),(PLACE(2),CM)
      D'N SAVEC(29)
      DEFINE UNARY OPERATOR .M., PRECEDENCE SAME AS .E.
      MODE STRUCTURE 2 = .M. 1
CLA       B
TMI       LOC+3
PXA       ,0
TRA       LOC+2
CLA       =1
OUT       AC
END
      DEFINE UNARY OPERATOR .STZ., PRECEDENCE SAME AS =
      MODE STRUCTURE .STZ. 1
STZ       B
OUT       Z
END
      W'R MINTST, PRINT OCTAL RESULTS BOTTOM,TOP,EL,NOLINE
      W'R MINTST, P'T $S15,12C6*$,(I=BOTTOM-12,-12,I.L.TOP,B(I)...B
     1(I+11))
      (I=0,1,I.G.18,.STZ.MINUS(I),.STZ.PLUS(I))
      COLS = 72 - STATE
      .STZ. QQZ
      SLIST = 0
      ELQ = EL .A. (777777K)
      ELI = ELQ .A. (777K)
      BEGIN = EL1 * 5 + 1
      BEGIN1 = BEGIN + 1
      J = 77777K
      SET.(J,QQ,CARD,OUTPUT)
      SELM = $$
      T'H COLECT, FOR Q = BOTTOM -12, -12, Q .L. TOP
      .STZ. SAVEC
     R              LOOP TO STEP THROUGH THE REGION WHERE THE CARD
     R              IMAGES ARE STORED, Q BEING THE BEGINNING OF EACH
     R              SEPARARTE CARD IMAGE
      SPREAD.(B(Q),$72C1*$,CARD...CARDE)
      W'R MINTST, P'T $1H 12C6*$,B(Q)...B(Q+11)
```

```
R              CHECK TO SEE IF IT'S A COMMENT CARD
 W'R CARD(COL) .E. COMLET
R                     IS IT A COMMENT CARD
 P'T FUN, CARD...CARDE
 PUNCH FORMAT $72C1*$,CARD...CARDE
 T'O COLECT
 O'R CARD(COM) .NE. $$
 W'R MINTST, P'T ZICK, 001
R                     IS IT A CONTINUATION CARD
 START = STATE
 START1 = STATE
 O'E
 W'R MINTST, P'T ZICK, 002
 START = 77777K
 START1 = 0
 E'L
R                     AT THIS POINT, COMMENT CARDS
R                     HAVE BEEN PRINTED OUT, CONTINUATION
R                     CARDS FLAGED
 FIND.(MIN0,CARD,MINUS,71,START1)
R                     LOCATE ALL PLUS AND MINUS ZEROS
 FIND1.(PLUS0,CARD,PLUS)
 W'R PLUSF .OR. MINUSF, P'T $3813*$,MINUS...MINUS(18),PLUS...
1PLUS(18)
 W'R MINUS .E. 0
 W'R MINUSF, P'T ZICKM, 001
 MINM = 77777K
 O'E
 MINM = MINUS(1)
 NEXTM = 3
 E'L
 NEXTP = 1
SCAT
 W'R PLUS .L. NEXTP
 W'R PLUSF,  P'T ZICKP, 001
 MINP = 77777K
 O'E
 MINP = PLUS(NEXTP)
 NEXTP = NEXTP + 2
 E'L
 T'O TEST
LABEL
 W'R MINUS .L. NEXTM
 W'R MINUSF, P'T ZICKM,002
R                     HAVE ALL MINUS ZEROS BEEN PROCESSED
 MINM=77777K
 O'E
R                     IF NOT, GET THE NEXT ONE TO BE PROCESSED
 MINM = MINUS(NEXTM)
 NEXTM = NEXTM + 2
 E'L
TEST
 W'R MINP .L. MINM
 W'R PLUSF,  P'T ZICKP, 002
R                     ENTER HERE IF NEXT SUBSTITUTION IS TO BE
R                     FOR A PLUS ZERO
 MOVE.(START,MINP-1)
 ELM = ELQ
 STIP = PLUS(NEXTP-1)
```

```
 START = STIP
 KKL = 0
 T'H CHECK1, FOR VALUES OF LETTER = LPAREN, RPAREN, COMMA
 W'R PLUSF,  P'T ZICKP, 003
R                    FIND OCCURENCES OF -(-, -)-, -,-
R                    BETWEEN PLUS ZEROS
 COUNT = 0
 COUNT(1) = 0
 FIND.(LETTER,CARD,COUNT,STIP-1,MINP+1)
 W'R COUNT .G. 1
 MOVE.(MINP-1,STIP)
 PRINT COMMENT $0**** ILLEGAL NO. OF CHARACTERS ON FOLLOWING C
1ARD.$
 T'O SCAT
 O'E
 PLACE(KKL) = COUNT(1)
 E'L
 KKL = KKL + 1
CHECK1
 W'R .NOT. RPK, RP = STIP
 W'R .NOT. LPK
 W'R PLUSF,  P'T ZICKP, 004
 LP = MINP
 PAR = $$
 C'E
 PAR = WORD.(MINP,LP)
 E'L
R                    NOW HAVE PARAMETER NAMES IN PAR ---
 W'R PAR .E. $$, PAR = 0
 W'R PLUSF,P'T $H8 PARAMETER NAME = 8C6*$,PAR
 W'R CMK
 W'R WORD.(CM,RP) .NE. $$, ELM = -ELM
 W'R PLUSF,  P'T $H90ATTACHMENT IDENTIFIER IS 9C6,*$,
1WORD.(CM,RP)
R                    IF THERE IS AN ATTCHMENT IDENTIFER, FLAG
R                    IT
 C'E
 CM = RP
 E'L
 ELM = ELM .V. (SEARCH.(ATS(PELT(BEGIN)),PELT(BEGIN1)-1,WORD.
1(LP,CM),NOAT).LS.18)
 W'R PLUSF,P'T$H90 CM = 916,H8  RP = 816,H8  THE ATTACHMENT NA
1ME IS 8C6,H8  THE ELM WORD = 8K12*$,CM,RP,WORD.(LP,CM),ELM
R                    WE NOW HAVE A PACKED WORD CONTAINING
R                    /+ OR -/ ATT / EID / ELM /
 W'R .M. ELM
 W'R ELM .E. SELM, T'O OKK1
 PLUSF = 1B
 SELM = ELM
 FIND.(ELM,CONR,SAVEC,NOSOL,0)
 FIND3.(-ELM)
 FIND2.(ELM,CONL)
 FIND3.(-ELM)
 W'R PLUSF,  P'T ZICKP, 005
 W'R SAVEC .E. 0
 P'T $H9 *****  ERROR -- ELEMENT NOT FOUND....9*$
 QQ = 988
 O'E
 W'R PLUSF,  P'T ZICKP, 007
```

```
          JQJ = SAVEC - 1
          K = 1
TSTLIN
          QQ = SEARCH.(SAVEC(K),JQJ,NOLINE,OKK) + K
          W'R PLUSF,  P'T ZICKP, 008
          (I=QQ,1,I.G.SAVEC,SAVEC(I)=SAVEC(I+1))
          SAVEC = SAVEC - 1
          K = QQ
          JQJ = JQJ - K
          T'O TSTLIN
OKK
          W'R SAVEC .E. 1
          P'T $H9 ***** ONLY ONE OCCURENCE OF ELEMENT.9*$
          SAVEC = 0
         R              TURN OFF THE MULTI-SUBSTITUTION SWITCH
         R              AND PROCEED
OKK1
          W'R PLUSF,  P'T ZICKP, 006
          QQ = SAVEC(1)
          T'O QQERR
          O'R SAVEC .E. 0
          W'R PLUSF
          P'T $H90***** ELEMENT OCCURES ONLY ON THE PRESENT SOLUTION LI
         1NE.9*$
          E'L
          QQ = NOLINE
          T'O QQERR
          E'L
          SAVE = 1 + SAVE
          W'R PLUSF,  P'T ZICKP, 009
         R                   IF ELEMENT HAD AN IDENTIFER FOR THE ATT.
         R                   SAVE THE POSITIONS FOR LATER SUBSTITUTIONS
          W'R PARK
          W'R PLUSF,  P'T ZICKP, 010
          SAVE(SAVE) = J + 3
          C'E
          SAVE(SAVE) = J
          E'L
          QQ = SAVEC(1)
          TOOK = 1
          E'L
          O'E
          SECOND = 0B
OKK2
          W'R PLUSF,  P'T ZICKP, 011
          QQ = FINDEL.(ELM,CCNT-1,BAD)
          E'L
QQERR
          W'R PLUSF, P'S QQ
          W'R PLUSF, P'S SAVEC...SAVEC(SAVEC)
          W'R PARK
         R                   IF THERE WAS A PARAMETER, CHECK FOR BEING
         R                   BROAD SCOPE HERE
          ZQQ = SEARCH.(FPAR,PARCNT,PAR,NOPAR)
          W'R PLUSF, P'S ZQQ
          W'R GETBRD.(ZQQ,BWORDS)
          QQ = BROAD(QQ)
          W'R PLUSF, P'S QQ
          E'L
```

```
          PAR = ZPAR(ZQQ)
NOPAR     PSTO.(PAR)
          W'R PLUSF, P'T ZICKP, 012
          O'E
          R                    IF NO PARAMETER NAME, JUST STORE NUMBER(QQ)
          BCDNUM.
          E'L
          W'R PLUSF, P'T ZICKP, 013
          T'O SCAT
          O'R MINM .L. MINP
          W'R MINUSF, P'T ZICKM,003
          R                    ENTER HERE IF MINUS ZERO IS THE NEXT SUB.
          COUNT = 0
          MOVE.(START,MINM-1)
          START = MINM
          NXTM = NEXTM - 1
          FIND.(ASTRIC,CARD,SC,MINUS(NXTM)-1,MINM+1)
          R                    COUNT NO. OF ASTRICS
          W'R SC
          W'R MINUSF, P'T ZICKM,004
          SSC = COUNT(COUNT)
          C'E
          SSC = MINM
          E'L
          PAR = WORD.(SSC,MINUS(NXTM))
          W'R COUNT .E. 0
          W'R MINUSF, P'T ZICKM,005
          R              PAR CONTAINS A FUNCTION NAME
          PRINT COMMENT $0**** HEY ... YOO HOO ... HERE'S ONE.........$
          START = MINUS(NXTM)
          MOVE.(MINM,START-1)
          T'O LABEL
          O'R COUNT .E. 2
          W'R MINUSF, P'T ZICKM,006
          R              PAR CONTAINS A STATEMENT LABEL NAME
          QQ = SEARCH.(SLIST(1),SLIST(SLIST),PAR,GEN) * MULT
          PSTO.(PREFIX)
          T'O LABEL
GEN
          W'R MINUSF, P'T ZICKM,007
          SLIST = SLIST + 1
          SLIST(SLIST) = PAR
          R              ADD THE LABEL TO THE LIST
          QQ = SLIST * MULT
          PSTO.(PREFIX)
          T'O LABEL
          O'E
          MOVE.(MINM+1,MINUS(NXTM-1))
          PRINT COMMENT $0**** ILLEGAL NUMBER OF ASTRICS ON THE FOLLOWI
          1NG CARD.$
          R                    AN ILLEGAL NUMBER OF ASTRICS APPEARED
          E'L
          O'E
          W'R MINTST, P'T ZICK, 003
          MOVE.(START,71)
          QQT = Q - 12
          W'R B(QQT+CONW).A.MASK.E.MB.OR.QQT.L.TOP
          W'R MINTST, P'T ZICK,  004
CRD OUT
```

```
          W = 1
          P'T COUT,OUTPUT...OUTPUT(J)
          W = 0
          PUNCH FORMAT COUT, OUTPUT...OUTPUT(J)
          W'R FLAG
          W'R MINTST, P'T ZICK,  005
          TOOK = TOOK + 1
          W'R TOOK .LE. SAVEC
          W'R MINTST, P'T ZICK,  006
          QQ = SAVEC(TOOK)
          Z = J
          (I=1,1,I.G.QQZ,J=SAVE(I),BCDNUM.)
          J = Z
          T'O CRDOUT
          E'L
          W'R MINTST, P'T ZICK,  007
          .STZ. QQZ
          SELM = $$
          E'L
          W'R MINTST, P'T ZICK,  008
          J = 77777K
          E'L
          W'R MINTST, P'T ZICK,  009
          E'L
          W'R MINTST, P'T ZICK,  010
COLECT
          W'R MINTST, P'T ZICK,  011
          MULT = MULT + 1
          F'N
          P'R ZICK(ZICKI)
          I'N FINDEL.(SEL,CNT)
          W'R TSTSCN, P'T ZICK, 032
          SSD = 1B
          E'O FINDL.
          W'R TSTSCN, P'T ZICK, 033
          W'R SSD
          W'R TSTSCN, P'T ZICK, 034
          F'N SEARCH.(CONL,CNT,SEL,NELM1)
NELM1     SSD = 0B
          W'R TSTSCN, P'T ZICK, 035
          E'L
          W'R TSTSCN, P'T ZICK, 036
          F'N SEARCH.(CONR,CNT,SEL,NOELM2)
NOELM2    ERROR RETURN
          E'N
BAD
          W'R SECOND
          PRINT COMMENT $0**** COULDN'T FIND ELEMENT ON THE LIST.$
          QQ = 987
          T'O QQERR
          E'L
          SECOND = 1B
          ELM = -ELM
          T'O OKK2
NOAT      PRINT COMMENT $90***** ATTACHMENT COULD NOT BE FOUND IN ATS T
         1ABLE.$
          P'S PELT(BEGIN)...PELT(BEGIN+4),ATS(PELT(BEGIN))...ATS(PELT(
         1BEGIN1)-1)
          MOVE.(Z-1,STIP)
```

```
 T'O SCAT
 P'R ZICK(ZICK)
 V'S FUN =$1H 72C1*$
 V'S ASTRIC = $*$
 V'S COL = 10
 V'S COM = 10
 V'S COMLET = $R$
 V'S COMMA = $,$
 V'S CONW = 1,0
 V'S COUT =$,W'(1H )72C1,'FLAG'(/8('W'(1H )T'COL',1H1'COLS'C1)
1 )*$
 V'S ERK = $H90***** TOO MANY ASTRICS (*) IN SPECIFICATION ON
1CARD 9/12C6*$
 V'S MIN0 = $0$
 V'S LPAREN = $($
 V'S MULT = 1
 V'S PLUS0 = $0$
 V'S PREFIX = $ZZW$
 V'S RPAREN = $)$
 V'S STATE = 11
 V'S TSTSCN = 1B
 V'S MASK = 7700K
 V'S MB = 6000K
 FORMAT VARIABLE COL, COLS, W
 FORMAT VARIABLE FLAG
 BOOLEAN PARK,CMK,RPK,LPK
 BOOLEAN GETBRD.
 BOOLEAN FLAG
 BOOLEAN SC
 B'N SSD,SSSD
 B'N TSTSCN
 EQUIVALENCE (CARD(71),CARDE)
 EQUIVALENCE(PARK,PAR),(RP,RPK),(LP,LPK),(CM,CMK)
 EQUIVALENCE (COUNT,SC)
 EQUIVALENCE (SAVE,QQZ,FLAG)
 EQUIVALENCE (SSD,SSSD)
 D'N MINUS(18),PLUS(18)
 D'N OUTPUT(659)
 D'N COUNT(4)
 EQUIVALENCE (Z,MINP)
 B'N SECOND
 V'S MINTST = 0B
 V'S PLUSF = 0B
 V'S MINUSF = 1B
 V'S ZICK = $H9 *****  SSCAN -- GENERAL TRACE STATION 9I5*$
 V'S ZICKP = $H9 *****  SSCAN -- PLUS TRACE STATION 9I5*$
 V'S ZICKM = $H9 ***** SSCAN -- MINUS TRACE STATION 9I5*$
 V'S ZICKI = $H9 *****  SSCAN -- INTERNAL FUNCTION STATION 9I5
1*$
 V'S TSTSCN = 0B
 E'N                                                              *
```

```
$ASSEMBLE,PUNCH OBJECT                                          SEARCH00
*****************************************************************************
*       SEARCH  SIMULATOR CORE4                          BOYD NOV 64
*       CALLED BY SSCAN1
*
*       ROUTINE TO SEARCH A LIST LOOKING FOR A SPECIFIC ENTRY
*       RETURNS IN AC LIST SUBSCRIPT WHERE ENTRY IS FOUND
*       IF THE SAME ENTRY OCCURS MORE THAN ONCE ONLY THE LAST WILL BE FOUN
*
*       ARGUMENTS
*       1,4     ZERO LOCATION OF LIST
*       2,4     LAST ENTRY ON LIST
*       3,4     WORD TO BE FOUND
*       4,4     EXIT IF ENTRY NOT FOUND
*
*       CALLED FROM SSCAN1 TO SCAN FPAR LIST FOR VARIABLE NAMES, SO THAT
*       THE UNIQUE THREE CHARACTER NAME CAN BE FOUND ON THE ZPAR LIST
*
*****************************************************************************
        ENTRY SEARCH
SEARCH  CLA     1,4                 ZERO LOCATION
        STA     CAS
        CLA*    2,4                 LAST ENTRY
        PAX     ,1
        CLA*    3,4
CAS     CAS     **,1
        TRA     *+2
        TRA     OUT                 WORD FOUND
        TIX     CAS,1,1             LOOP TO SEARCH BACKWARDS
        AXT     0,1
        CAS*    CAS                 CHECK ZERO LOCATION
        TRA*    4,4                 WORD NOT FOUND,  ERROR RETURN
        TRA     *+2
        TRA*    4,4                 WORD NOT FOUND,  ERROR RETURN
OUT     PXA     ,1                  WORD FOUND, PUT INDES IN AC
        TRA     5,4                 NORMAL RETURN
        END                                                             *
```

PART B

REGRESSION PROGRAM

TABLE OF CONTENTS

INTRODUCTION

In every system for which simulation is an important method of analysis there are many components or elements whose behavior must be modeled. In some cases, there may exist sufficient theoretical background in physics, mathematics, and allied sciences to allow an analytical model to be derived. But in most cases the real world physical element will behave somewhat differently from the performance expected by theoretical considerations alone. Real world "noise" such as gearing friction, surface roughness, and variations in physical properties conspire to cause the actual components to deviate from ideal behavior.

In other cases, particularly in new fields of exploration, there may not yet exist sufficient evidence to complete an analytical modeling. In fact, it is the true purpose of experimentation and test to build the basis of facts required for such analysis.

The Regression Program described in this report can be of major assistance in each of the foregoing situations. This procedure -- developed over a period of several years and applied in many diverse areas of physical and sociological systems -- enables the careful researcher, engineer, or scientist to explore an apparently unrelated set of data for relationships that can be of significant help in deriving both an analytical model of the phenomenon and, later, an insight into the nature of the process itself.

The Regression Program builds such a model with the assistance of the experimenter and tests this model against the set of observations supplied. In the process a heuristic model of the phenomenon is constructed and used to explore the problem further beyond the initial help supplied by the experimenter. Because most realistic systems problems permit so many possible terms and variables, the heuristic procedure reduces an almost impossible, if not economically prohibitive , exhaustive search through all possibilities to a much smaller problem in adaptive processes.

The following three sections are designed to (1) provide an understanding of this procedure and (2) give detailed instructions on the method of using this computer program and preparing the data for this analysis. Those readers desiring to use the program in specific problems may use the third section as a manual. It should be pointed out that very little information is absolutely mandatory. The "standard" values

supplied by the program in the absence of specific instructions from the user have been selected after many, many uses of the program. These values will allow a new user to get some results almost immediately. But with experience in particular problems the user may wish to supply other values to get improved performance.

In addition, new features allow the user to insert special arbitrary functions to be used in the regression analysis. Prior to this development the user who had some insight leading him to wish, say, an exponential or sinusoidol function to be employed did so with considerable difficulty.

These and other innovations are detailed in the following sections.

SECTION I

GENERATION OF A PREDICTING EQUATION

Consider a simple example; suppose that an experiment has been made consisting of a set of observations of six variables. Regarding one of the six as a dependent variable and the remaining five as predictor or independent variables, the analysis determines the "minimal" set of variables which may be used in a relation of the form

$$Y = b_0 + b_1 X_1 + b_2 X_2 + \ldots\ldots + b_p X_p \qquad (1)$$

where, in this case, $p = 5$.

The first step is to find that variable X_i which best predicts Y. This is done by correlating each of the X_i to Y and selecting that X_i which has the greatest "correlation coefficient"* in absolute value. If more

---

*The correlation coefficient is defined as the product-moment coefficient of correlation: Let

$$X_i X_j = \sum_t W_t X_{it} X_{jt} - \frac{(\sum_t W_t X_{it})(\sum_t W_t X_{jt})}{\sum_t W_t}$$

where
- t = number of observations
- n = number of independent variables
- j = $i, i+1, i+2, \cdots, n+1$
- i = $1, 2, \cdots, n+1$.

Then let

$$\alpha_i = \sqrt{X_i X_i} \quad i = 1, 2, \cdots, n+1$$

and the correlation coefficient r is then

$$r_{ij} = \frac{(X_i X_j)}{(\alpha_i)(\alpha_j)}$$

with the properties

$$r_{ji} = r_{ij} \qquad i, j = 1, 2, \cdots, n+1$$
$$r_{ii} = 1.000$$
$$-1 \leq r_{ij} \leq 1.$$

than one X_i shares the largest value, take the X_i with the lowest subscript i. That is, take the first such X_i encountered. Suppose that in this instance that best i is 4. The first predicting equation is then

$$Y = b_o + b_4 X_4 . \qquad (2)$$

The b_o and b_4 satisfy the least-squares criterion.

Succeeding steps are of slightly different form. First, the X_i are sorted into two subsets $X_{i,1}$ and $X_{i,2}$. The set $X_{i,1}$ consists of all those variables that are in the predicting equation at the time of sorting. The set $X_{i,2}$ consists of all those variables that are not yet in the predicting equation.

For each of the members of $X_{i,1}$ the analysis computes an "importance factor"** which is a measure of the relative contribution of the variable to the predicted equation. The smallest of these importance factors is

** The "importance factor" is found by using the variance contribution for each variable. Initially, the correlation matrix r_{ij} defined earlier is equal to the regression matrix a_{ij}

$$a_{ij} = r_{ij} ; \quad i, j = 1, 2, \cdots , n+1.$$

Then the variance contribution for the i-th variable is:

$$V_i = \frac{a_{iy}\, a_{yi}}{a_{ii}} \quad i = 1, 2, \cdots , n$$

and where the subscript y is understood to be the dependent variable subscript (n +1).

NOTE: If $V_i > 0$, then X_i is not yet in the regression equation and the $V_i > 0$ may be regarded as the relative contribution by the respective X_i in explaining the as yet unexplained variance in the dependent variable Y.

If $V_i < 0$, then X_i is currently in the regression equation. The $|V_i|$ for all $V_i < 0$ may be regarded as the relative contribution by the respective X_i to the regression prediction of Y.

As each term is added or deleted from the regression equation, the regression matrix a_{ij} is modified to contain the corresponding effect.

isolated. If the variable associated with this factor is less important than the user requires for the variable to be retained in the equation, then that variable is removed from the equation before continuing.

The scale used to determine whether a variable meets the "importance" criterion is simply the probability or chance that the user is willing to take that a variable may be left in the predicting equation that should have been removed. The F-test measures the extent to which a variable will contribute toward explaining the dependent variable behavior, and tests this contribution against a purely chance correlation by comparing the variance with and without the term. The hypothesis tested is that the variance is equal in both cases and that any difference is due only to chance. Thus, the term will be used only when the difference in variance cannot be explained by chance alone. Thus, if one selects a probability of committing an insertion error (that is, inserting a term into the predicting equation that really does not belong in the equation) and finds the number of degrees of freedom (roughly the number of weighted observations), the value of F indicated by the surface is such that if the value of F displayed by the "best" term exceeds the value on the surface, then the risk is less than the probability chosen. As might be expected, the value of F on the "threshold" surface goes to zero as the probability goes to 1 (certainty of committing an error). In that case, any non-negative value of F equals or exceeds the "threshold" and the result would be to insert every term whether correlated or not. Conversely, if one goes toward zero probability (certainty of not committing an error) the threshold value grows, approaching infinity in the case of zero probability. Thus no value of F can exceed this threshold and so no terms can be inserted. For any reasonable probability, the effect of the number of data can be assessed. As the number of data grows large, the "threshold" value approaches a constant dependent only on the probability. As the number of data approach zero, the risk of error is held constant by requiring larger and larger F values with infinity as the value corresponding to "no data." With such a test, the Stepwise Regression Program can control the generation of a predicting equation so that each term possesses a maximum risk of appearing incorrectly. Of course, many, perhaps most, terms actually appearing in the final equation exceed the threshold by substantial amounts and thus represent greatly reduced risks. The test insures that every term is at least as good as the risk specified.

If the user takes a probability of error for removing variables of 0.05 then the odds are 1 in 20 that a term may be left in the predicting equation incorrectly. Obviously, if the user wants to make this error

very rarely, he may set the probability of that error very low, say 0.01 or 0.001. This situation requires one additional remark. When one asks that the chance of committing an error be made small, the chance of committing the converse error must become large. In this case, one increases the risk of removing variables that really belong in the equation by decreasing the risk of leaving variables that do not belong in the equation. If the chance of leaving a variable incorrectly were set by the user at 1 in 10,000, it is also possible that insufficient data may have been accumulated to allow the retention of any variables in the equation, and the analysis can do no more than predict the average value of the dependent variable Y by the appropriate b_0. The remedy is clear: if one wishes to set high standards, the price is additional experimentation to produce additional evidence to support the case.

If and when all the importance factors exceed the minimum value required for retention of the set $X_{i,1}$, the analysis then examines the set $X_{i,2}$. For each element of this set a "potential importance factor" (as defined earlier), is determined and the largest of these isolated. These factors measure the relative contribution which each variable not presently in the predicting equation might make to the equation if it were put in. The largest of these is associated with the "best" variable at this stage. Once again a comparison is made to insure that the risk of inserting a variable incorrectly is in agreement with the significance of the "best" variable before the insertion is allowed to occur. Again, the user specifies the risk he is willing to take of a variable being incorrectly inserted into the predicting equation, understanding 0.05 to mean 1 chance in 20 of the error occurring and recognizing that reducing the chances of incorrectly inserting variables increases the chances of omitting correct variables from lack of evidence.

Suppose that, in the example considered, X_4 has been retained, and that of X_1, X_2, X_3, X_4, the variable X_1 best explains the behavior of Y not explained by X_4. If there is sufficient evidence to support the insertion of X_1, then a new predicting equation is formed by least squares:

$$Y = b_0^{(1)} + b_1 X_1 + b_4^{(1)} X_4 . \qquad (3)$$

The superscripts on b_0 and b_4 indicate that these coefficients have undergone one modification in the process and are new values. At this point the variables are again sorted and checked for importance and the procedure repeated. The analysis ceases when either all the X variables have been inserted into the predicting equation or none of the X variables that remain as possible candidates for the equation is sufficiently important to allow insertion.

Continuing the example, suppose that on the third step X_5 is introduced, yielding:

$$Y = b_0^{(2)} + b_1^{(1)} X_1 + b_4^{(2)} X_4 + b_5 X_5. \quad (4)$$

Further suppose that X_1 and X_5 behave together in such a way that the results is like having X_4 in the equation twice. In such a case, the importance of X_4 might be considerably reduced. Suppose that this is the case and that the importance of X_4 falls below the limit set by the user. Then X_4 is removed and the equation becomes:

$$Y = b_0^{(3)} + b_1^{(2)} X_1 + b_5^{(1)} X_5. \quad (5)$$

In step (5) suppose that X_2 is added giving:

$$Y = b_0^{(4)} + b_1^{(3)} X_1 + b_2 X_2 + b_5^{(2)} X_5. \quad (6)$$

Now suppose that neither X_3 nor X_4 are sufficiently significant to allow their insertion. The final prediction equation produced is (6). The analysis makes available a number of statistics at each step which may be interpreted as a measure of goodness of fit or prediction as well as the b values and the importance level for the term considered at that step.

The Statistical Model

Suppose that the physical system giving rise to the preceding example was such that it could be hypothesized that the system could be characterized or described by the mathematical model:

$$Y = B_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + B_4 X_4 + B_5 X_5 + E, \quad (7)$$

where the B_i ($i = 0, 1, 2, \ldots, 5$) are unknown and possibly some of them may be zero. E is a random error variable term which accounts for the inability to obtain strictly reproducible data when observing the

physical system. Setting aside the consideration of E for the moment, the problem is that of obtaining the best estimates of the B_i. It may be observed immediately that this is the problem just considered, resulting in Equation (6), and that the B_i are estimated by b_i, respectively. The best estimates of B_3 and B_4 are zero.

Turning attention once again to E in Equation (7), it is clear that Equation (6) is not quite complete. The randomness of E makes the prediction of E impossible. What is possible is the determination of the likelihood of E being inside a range of values. In other words, because of E the measurements obtained are not exactly repeatable even if all the X's could be set at exactly their former values. Therefore, the estimates are possibly, but not necessarily, in error due to the influence of E. A more nearly complete treatment of Equation (7) would

(1) estimate the B_i as before;
(2) estimate the possible errors in the B_i; and
(3) estimate the variability of E.

The Stepwise Regression Program automatically estimates each of the three items desired. The estimate of the B_i has already been discussed. The possible errors in the B_i are indicated by quantities S_{Bi} called the "Standard Error of the Coefficient" for each i. These values are such that if one forms the interval

$$B_i - S_{Bi} \leq B \leq B_i + S_{Bi} \tag{8}$$

then the "true" value of B may be expected to be included by this interval in about 68% of all cases. If one extends the interval to form

$$B_i - 2S_{Bi} \leq B \leq B_i + 2S_{Bi}, \tag{9}$$

then this interval should include the true value in about 95% of all cases.

The variability of E is measured by a statistic called "The Standard Error of Estimate". This is roughly the standard deviation of the E. Adding additional terms to the predicting equation usually results in reducing the standard error of estimate. The amount of reduction is a measure of the contribution made by that variable toward the explanation of Y. When the analysis is completed, this statistic measures the behavior of Y not explained by the predicting equation and reflects the remaining observational errors and, of course, possible errors in the

hypothetical model. The precision of the predicting equation is reflected by the magnitude of the Standard Error of Estimate (Sy) such that if one uses the predicting Equation (6) to estimate Y and then forms a band about the curve predicted by (6) of plus and minus Sy (i.e., the band is 2Sy in width and centered on the curve from (6)), then the "true" value of Y may be expected to be included by this band in about 68% of all cases. Again, doubling the band width to ± 2Sy raises the expectation to about 95% of all cases. In other words, when enough experimental observations of a physical system are made accurately on good instruments so as to minimize observational errors, and when the hypothetical model correctly describes the physical system, then Sy will be small and the predicting equation may be used to estimate Y with a measure of the precision of this estimate interpreted as indicated.*

The analysis produces two other valuable statistics at each step of the estimation process. The "Coefficient of Determination"** is interpreted as the proportion of the total variation in Y that is explained by the predicting equation. The possible values lie in the range from +1.00 (perfect prediction) to 0.0 (no prediction). Statisticians familiar with the "Multiple Correlation Coefficient", which is the positive square root of the Coefficient of Determination, will find it displayed also.

---

*It should be mentioned in passing that the interpretation of Sy and S_{Bi} should be as stated here and that it is <u>not correct</u> to say that about 68% of all <u>observed</u> values will lie within the intervals indicated for ± S and so on.

**The Coefficient of Determination (R^2) is found by subtracting the regression matrix element a_{yy} (which measures the dependent variable variance) from unity. That is, $R^2 = 1. - a_{yy}$.

SECTION II

ARTIFICIAL INTELLIGENCE APPLIED TO THE STEPWISE REGRESSION METHOD

Section I of this discussion treated the use of the Stepwise Regression Method as it applied to those cases in which the entire set of variables and functions of variables can be represented by a single collection of small enough size to allow complete retention within the memory of the machine. While some expansion might be realized by adroit programming, a little study of the nature of the problem indicates that an expansion in capacity of several orders of magnitude together with a new concept of programming will be required to handle problems of the types commonly encountered in research.

To understand the nature of the problem encountered, consider the following example. Suppose that, as in the example of Section I, an experiment has been made consisting of a set of observations of six variables. Once again we regard one of the variables as a dependent variable and the remainder as predictor or independent variables. Assuming for the moment that only linear behavior is to be expected from any variable (a drastic simplification), it is apparent that the formal relation

$$Y = b_o + b_1 X_1 + \ldots + b_p X_p \qquad (1)$$

is not completely descriptive of even this simplified case. This is because of the possible existence of interactions between variables. Extending the example proposed to include interaction requires the inclusion of sets of terms of the forms

(1) X_i,

(2) $X_i X_j$,

(3) $X_i X_j X_k$,

(4) $X_i X_j X_k X_l$

and, in this case, the single term $X_1 X_2 X_3 X_4 X_5$ as possible candidates for the predicting equation. The number of such terms is found in the following way.

Let there be K groups of n_i distinct objects (i = 1, 2, ... , k) and let there be selected j objects

$$j \leq \sum_{i=1}^{K} n_i$$

at a time to form combinations. The number of such combinations is readily obtained for the case $n_i = 1$ for all i (the present example case). The number is (for $n_i = 1$)

$$N_j = K!/(K - j)!\, j!$$

and the case of K = 5 produces the table.

TABLE OF N_j FOR $n_i = 1$ and K = 5

j	N_j	$\sum N_j$
1	5	5
2	10	15
3	10	25
4	5	30
5	1	31

The table shows that even the simple example chosen has expanded the required storage capacity from a 6 + 1 square matrix of 49 locations to a 32 + 1 square matrix of 1089 locations. Furthermore, the usual problem does not permit the assumption of $n_i = 1$. The more general case may be determined if

(1) n_i is constant for all i;
(2) selection occurs always between groups and not within groups.

Then

$$N_j = \left[K!/(K-j)!\,j!\right] n_i^j \,. \qquad (13)$$

Condition (1) is not unreasonable and condition (2) simply requires that n_i be large enough to include whatever terms might be desired to be generated within the smaller group. That is, if one considers X^2 and X^3 and wishes also to consider $X^5 = X^2 * X^3$, then condition (2) requires that X^5 be made a member of the n_i (and not generated from X^2 and X^3).

Suppose that in the example, 10 function choices are suggested for each of the five variables (the use of 20 or more is not uncommon in problems concerning a single independent variable). Neglecting interactions the problem requires 52 * 52 locations. Considering interactions and using (13), one obtains the table:

TABLE OF N_j FOR $n_i = 10$ AND $K = 5$

j	N_j	N_j
1	50	50
2	1000	1050
3	10000	11050
4	50000	61050
5	100000	161050

Obviously this is outside the range of even projected computers since the matrix now requires $(161052)^2$ locations.

Conventionally, work has progressed in this field by the expedient of setting the coefficients of all but a very few of these terms identically equal to zero. The formal relation (1) is such a reduction. This method, while enabling some attack to be made on otherwise nearly hopeless problems, suffers greatly for several reasons. First of all, the choice of omitted terms is a process of discarding thousands of terms to retain one. Secondly, the usual practice of relying on apparent fit to select terms before the regression process begins may result in the omission of exactly the terms needed.*

*Experience with the regression program on single independent variable problems indicates that the terms added successively to the predicting equation bear little relation after the first step to their partial correlation coefficients with respect to the dependent variable. This is because the added terms are always charged with explaining the as yet unexplained variation in the dependent variable. Consequently, if the first term entered explains the dependent variable behavior quite well, the next term may be of quite different character in order to explain what is left by the first term.

A procedure is needed to conduct a search through thousands of possible terms engaging only a few dozen at a time to produce the predicting equation. To be as effective as possible, it would be very desirable to use each experience with the problem, whether successful or not, to learn more about the nature of the terms that are generally useful and thereby accelerate the search. Such techniques as "learning" and the "acquiring of experience" are generally associated with nonmechanistic organisms. Since it is proposed that these techniques be simulated by the computer, this is the application of artificial intelligence to the problem.

The program has been written so that the machine is not presented with the condensed subset, as usually happens, but instead is given access to all possible terms and interactions within the bounds of the number of variables considered and the number of function choices per variable allowed. As usual in problems of this type, no straightforward procedure can be given to proceed to the solution that does not also appear economically prohibitive. It is not a matter of instructing the machine how to solve the problem, but instead of instructing the machine how to "learn" to solve the problem. Specifically, the machine must "learn" how to select terms so that the set of terms chosen contain those terms needed to produce predicting equations of high precision. Much remains to be done in this new and vital area. The present effort contains only the most rudimentary learning but is written in such a way that more sophisticated learning models can be inserted fairly easily. Experience with the simple learning mechanism has been extremely encouraging.

Turning to the example of 5 variables and 10 functions per variable, the following discussion describes the nature of the learning scheme used by the program. Suppose that no knowledge of the nature of the more likely terms nor of the relative importance of the various term classifiers are known a priori. A "term classifier" is one of the set of (1) interaction order identifier, (2) variable identifier, or (3) function identifier, and is used to classify terms as to the degree of interaction, variables involved, and functions of variables involved in the term. If such knowledge is presumed known before commencing the solution, means are provided to suggest either the initial set of terms to try or the initial distribution of weight among the term classifiers or both or neither. In the present case, neither are assumed to be supplied so the discussion may be understood for any other case where more information is given initially.

Since term classifiers are not assumed to be supplied, the program assumes no previous experience with the problem and accordingly sets the relative likelihood of all terms equal. This is accomplished by considering each of the classifiers as an array the elements of which are the lengths of the components of a vector. Each component is initially set to a unit length.

Next the initial set of terms must be generated by the program. Each of the 161050 possible terms in this example are equally likely at this state. The program uses a pseudo-random number generator to select (1) an interaction classifier, (2) variables to satisfy the interaction selected, and (3) a function for each variable chosen for the interaction. As each term is selected, a check is made to be sure that it is not a duplicate of an earlier term chosen for the current pass. When the number of terms (less than 60) requested by the user for each pass have been chosen and entered in a term matrix, the program calls upon an editor program to examine the data and the term matrix and thereby generate the set of edited data required by the regression analysis program. The editing process consists of operating on the raw data by referring to the term matrix for the definitions of the terms and to subroutines to carry out the generation of the terms. Each raw observation is converted into the edited data and a magnetic tape recording of the result is made. When all the data have been edited, the program turns to the Stepwise Regression Program to carry out the analysis exactly as before with respect to the set of terms chosen by the program. Upon completion of the Regression Program for this selection of terms, a check of the generated predicting equation is made to see if:

(1) the Coefficient of Determination is as large as the user specified,

(2) the Standard Error of Estimate is as small as the user specified,

(3) the number of passes executed have not exceeded the limit by the user.

If further work is allowed as the result of these checks, the program proceeds to examine the results of the pass just completed and in so doing acquires "experience" concerning the types of terms most suitable for future use.

This "experience" is acquired by the student program as follows. Each term is checked against the list of terms included in the predicting equation. If a term has been successfully used in the relation, the student (1) retains the term to be used again, and (2) increases the probability of trying similar terms by incrementing the lengths of the vector components of the classifier arrays that chose the terms. If the term was not successful, the student decrements the lengths of the vector components that selected the term. By modifying the vectors by amount proportional to their current size, no term will ever be reduced to zero probability but may have its probability made arbitrarily small but positive. In this way the arbitrary setting of huge blocks of coefficients to zero is avoided and any term may at any time be used successfully and thereby become a member of the predicting equation until supplanted by a still better term.

After the student program completes the study of the previous run, the "experience" gained is utilized to select a new set of trial terms for the next pass. This is to say, the previously successful terms are retained from the former pass and the term matrix is filled out with terms chosen by using the modified classifier arrays and the random selection process. Since the classifier arrays have been modified, the selection of new terms no longer occurs with equal probability for all interactions, variables, and functions. Thus the search is less random and becomes more nearly stepwise as success and failure direct the modification of the classifier arrays. So long as it is possible to retain terms used successfully on the previous pass and still select some additional term or terms, the program retains the previously successful terms. In this way, the new pass will always be at least as "successful" as the last pass. If, however, a new pass is called for and there is no room for additional terms, the program has encountered a "traffic jam" since a new pass would not be requested if the old selection had been good enough. In this situation, a fresh start is needed but old "experience" may still provide valuable assistance in the selection of term. The student program discards the old selection of terms (printout of the discarded set is automatic so that human study can be made of it) and selects a complete new set while retaining the "experience" imbedded in the classifier arrays. In this case the machine is completely able to handle the "traffic jam" without outside help.

Another pitfall which might be encountered by the program concerns the case in which the solution has progressed to a locally maximally successful predicting equation. In this case, any change appears to make the predicting equation less useful and yet the present predicting equation is not good enough. An interesting property of the Stepwise

Regression method for choosing the most desirable terms results in the ability of the program to work itself out of such a situation. In fact, several instances have been observed in which the program accepted somewhat poorer overall fits for one or two trials in order to retain particularly good terms and on a succeeding trial found the fitted predicting equation to be several times better than the best previous equation.

In any case the process repeats itself, studying, grading, selecting, editing, fitting, until the conditions on the goodness of fit are met or until the desired number of passes have been used whichever comes first. While one cannot be certain that the very best predicting equation possible has been found after any predetermined number of passes (a characteristic of iterative process generally,) the procedure insures that the best solution to date is preserved and that all trials contribute to the improvement of the selection process.

The learning scheme employed by the student program embodies many of the principles discussed by Friedburg, Dunham, and North in their articles on "learning Machines" in the I. B. M. Journal. The student program extends these ideas and incorporates the advantages of both random search and stepwise search. Initial passes search rather randomly looking for promising leads. As evidence accumulates, the mode of search becomes increasingly stepwise as the number of "good" terms retained grow. Thus the search narrows itself into promising areas and progress is made toward solution until either a solution is found or the allowable number of passes is exceeded or until a "traffic jam" forces the random search to begin again. Random searching of the early stages is most promising since a poor start does not inhibit progress. Later stages have experienced some success and therefore the modifications are less drastic to allow the previous leads to be followed as far as they may prove to be profitable.

During the solution of any particular problem, it may happen that, when the data are operated upon by the editor program to produce the edited data, the size of the numbers generated may overflow or underflow the size of the computer word. In floating point arithmetic this may occur whenever the editor produces a non-zero number with absolute value outside the range 10^{-18} to 10^{+18} because of a later production of the sums of the squares and cross products of the terms by the Stepwise Regression Program. In these circumstances, the student program cannot experience "learning" for those terms of correct size since they have not yet been tried for the actual curve fitting, but the student program must "learn" about the selection of terms acceptable

to the computer. Occasionally, it has been observed that the terms suggested by the curve fitting process and the terms acceptable in size to the computer may not agree. The present learning mechanism is capable of correcting itself in this case without requiring human intervention.

Some final remarks may be of assistance in understanding the analysis. First of all, a given set of data may result in more than one predicting equation of a specified goodness of fit. This corresponds to the existence of several mathematical models of the system. Classically, this situation leads to the development of experiments capable of distinguishing between the models and the retention of those models which best describe the greatest variety of consistent circumstances accurately. By randomly restarting the problem this possibility may be investigated. If the program produces different predicting equations upon random restarting, more evidence is needed. Failure to produce different equations, however, does not guarantee freedom from such difficulty but decreases the probability of this difficulty. Secondly, if previous experience with a problem is available, prudence usually dictates that the initial pass make full use of it. The program provides ready means for saving previous results and for restarting with any or all of the previous classifier arrays and term selections intact. This same philosophy may be extended to initial runs in which the user's training and experience or previous encounters with similar problems may serve to generate an initial selection and/or weighting. The penalty for a poor guess is an increased number of passes, but a good guess results in considerable saving.

The Stepwise Regression Program with Simple Learning has been used successfully on many test problems and actual physical component modeling problems. In addition, interest in this technique has been generated in many diverse areas of the physical and social sciences. The ability to know precisely the worth of each and every term in a predicting equation, as well as the worth of the equation as a whole, as it is supported by actual evidence, should enable extensions of knowledge in many fields.

SECTION III

COMMUNICATION OF INFORMATION TO THE REGRESSION PROGRAM

Information governing output (printed and punched), type of analysis to be executed, amount of initial experience, and descriptions of the observations and variables, is conveyed to the program through several control cards. Parameter values are punched on these cards according to the write-up that follows. These control cards are placed directly after the $ DATA specification card (blue). Information on how to read the control card write-up follows.

With every run there must be four control cards in this order:

1. Title Card
2. Second Control Card
3. Third Control Card
4. Learning Control Card

Depending on the contents of the problem control cards, one, several, or all of the following groups of cards may be required:

5. Ordered Term Insertion Cards
6. Data Deck

    6A. Format Specification Card
    6B. Observed Data Deck
    6C. Blank Data Set

7. Accumulated Learning Deck
8. Initial Pass Terms Deck

ITEM #6 MUST BE PRESENT IN EVERY RUN. Others are optional, but if included, must be placed in the exact order listed.

Mode

This is the mode of the parameter as used in the program. If integer, its value must be integer, and must be punched on the control cards without a decimal point.

If fixed point, its value may be any number within the RANGE as stated, and should be punched on the control cards with the decimal point in its proper place (i. e. XXX. XX)

If floating point, its value must be punched on the control cards with the floating point format (i. e. X. XXEXX)

If Binary Coded Decimal, any legal alpha-numeric character allowed by the MAD translater may be used.

Columns

The numbers referred to by columns are the actual column numbers on the control cards that contain value of the applicable parameter.

Standard Values

Certain of the parameters required on the following control cards may be left blank and the program will insert its own standard values. These values are listed as STD Value in the control card write up. If no STD Value is listed, and the card column pertaining to the parameter is left blank, the University of Michigan input routine will interpret it as a negative zero. This is different from zero. Hence if parameter (17) on control card 3 is left blank, the -0 will be interpreted the same as a -1 by the program. In most other instances, if an integer zero is desired, the field may be left blank.

Parameter Name

This is the name assigned to the parameter in the symbolic listing. These are of interest to those who have occasion to make an actual change in the program statements.

First Control Care: Title Card

MODE:	Binary Coded Decimal
RANGE:	Any legal alpha-numeric characters
COLUMNS:	2-72

The title card allows the user to present any title that may be desired to be printed at the beginning of a new problem. Only one card may be used and the title may appear anywhere within columns 2-72. Column 1

is reserved for a carriage control character. Consult the executive system write-up for the selection of carriage controls. Ordinarily the user will punch a numeric one in column 1 so that the problem print out will begin on a new page.

If a blank card is used, the printer will simply single space the paper.

Second Control Card

1) Estimate Coefficient of Determination

MODE: Floating Point

RANGE: 0. - 1.

STD. VALUE: .96

COLUMNS: 1 - 10

PAR. NAME: CODTRM

This parameter is the users estimate of the expected goodness of fit between the predicting equation surface and the data. Perfect agreement is represented by a value of 1.0; no agreement by 0.0.

2) Standard Error of Dependent Variable

MODE: Floating Point

COLUMNS: 11-20

PAR. NAME: SIGMAY

This parameter is the users estimate of the standard error of the dependent variable represented in this data. The value reflects the probable errors present in the data in units of the same kind as the data. The smaller the value of SIGMAY, the more difficult is the task of finding an acceptable function.

3) Probability of Insertion Error

MODE: Floating Point

RANGE: 0. - 1.0

STD. VALUE: .05

COLUMNS: 21 - 30

PAR. NAME: PRBIN

This value is the probability allowed by the user that the least significant term inserted into the predicting equation is erroneous. A value of .05 represents a risk of 1 chance in 20.

4) Probability of Deletion Error

MODE: Floating Point

RANGE: 0. - 1.0

STD. VALUE: .05

COLUMNS: 31 - 40

PAR. NAME: PRBOUT

This value is the probability allowed by the user that a term removed from the predicting equation for lack of support should have been allowed to remain in the equation.

The probability of deletion error must not exceed the probability of insertion error. If it does, the program may reject every term offered.

5) Tolerance for Division and Round Off Error

MODE: Floating Point

STD. VALUES: .0001

COLUMNS: 41 - 50

PAR. NAME: TOL

This value is a bound such that if the magnitude of any division is less than this value, no division will occur. This value is also used to limit round off error in the matrix manipulations.

6) Number of Independent (Predictor) Variables

MODE: Integer

RANGE: 1 - 59

COLUMNS: 51 - 55

PAR. NAME: NOIND

This value plus one is the total number of variables in the problem.

7) Number of Passes Allowed for this Problem

MODE: Integer

STD. VALUE: 3 (or 1 if the entire problem can be treated in one pass)

COLUMNS: 56 - 60

PAR. NAME: NOTRYS

This value is the allowed number of complete passes made on the problem. In general, several passes will be required. However, if the problem is simple enough (in terms of the number of possible terms that may be generated) it may be completed in 1 pass.

8) Number of Functions to be Considered for Each Independent Variable

MODE: Integer

STD. VALUE: 10

COLUMNS: 61 - 65

PAR. NAME: NOFNCT

The choice of functions to be used by the program is determined by the subroutine PFNCT.

Standard operation (no specially designated functions) provides for access to integer powers, integer roots, and their reciprocals. The extent of the set so generated depends upon the number of functions allowed. The order of functions is:

FUNCTION No. 1 ---------- X (I) . P. 1
2 ---------- X (I) . P. -1
3 ---------- X (I) . P. 2
4 ---------- X (I) . P. -2
5 ---------- X (I) . P. 1/2
6 ---------- X (I) . P. -1/2

and so on repeating the pattern of functions 3, 4, 5, and 6 above for each increasing integer.

If special functions are suggested by the user, the number of special functions must be subtracted from the total number of functions to obtain the number of standard functions that will be considered, for that particular run.

Parameter Value	Standard Functions
10	thru X (I) . P. -1/3
22	thru X (I) . P. -1/6
38	thru X (I) . P. -1/10

9) Number of Terms to be Tried at Each Solution Pass

MODE: Integer

RANGE: 1 - 59

STD. VALUE: 40 (or the size of the set of all terms, if possible)

COLUMNS: 66 - 70

PAR. NAME: NOTRMS

In general, the set of possible terms (i. e. products of functions of the independent variables) is very large. Thus it is not generally possible to try all possible terms at one time. The value of NOTRMS gives the size of the subset of terms to be investigated on each pass.

If it should be possible, because of the simplicity of a given problem to try all of the possible terms at one time, this value will be selected for NOTRMS. Otherwise, the most desirable value is one which permits the generation of enough terms to provide the adaptive simple learning feature of the program with some record of success and failure on which to base the choice of future terms.

Third Control Card

The first Ten Parameters Are Output Control

A numeric 1 suppresses the particular calculations and printing specified by the parameter. A zero or blank will represent no suppression.

Since in most cases, this represents a very sizeable output, the user is cautioned to select only those items of real interest. All ten parameters are integer.

	OUTPUT	COLUMN NO.	PAR. NAME
1)	Raw data	1	INFRWDA
2)	Raw sums of squares and cross products	2	IFRAW
3)	Average (mean) values	3	IFAVE
4)	Residual sums of squares and cross products	4	IFRESD
5)	Standard deviations	5	IFSIG
6)	Partial correlation coefficients	6	IFCOEN
7)	Intermediate steps in regression process	7	IFSTEP
8)	Predictions using the intermediate step	8	IFPRDI
9)	Predictions using the final equation	9	LEPRED
10)	Values of terms for each set of observations	10	IFPRNT

If all of the above are surpressed, the output will consist of:

1) A listing of the special functions included, if any, and their function number in PFNCT.

2) Definitions of terms used for each pass.

3) Final equation found for each pass, with pertinent statistics.

a) The F-level of the last term treated

b) The standard error of the independent variable

c) The coefficient of determination

d) The multiple correlation coefficient

e) The constant term, if any

f) The coefficients and their standard errors for all terms finally retained in the equation

4) The diagonal elements of the regression matrix. Use to determine whether the analysis terminated because of tolerance (TOL) problems or because of F-level of remaining terms not yet in regression equation.

For most applications, the automatically produced output is sufficient; however, the accumulated learning deck and the output external functions are generally desirable. The user is again cautioned against requesting all of the printout due to its size.

11) Output External Function Option

MODE: Integer

RANGE: 0 - 3

COLUMN: 11

PAR. NAME: IFOUT

The program punches and prints an external function as output that contains the predicting equation obtained after the last regression step. A numeric zero will give the subroutine in the MAD language, a numeric one, in the FORTRAN language, a numeric two, in both lanquages; and a numeric three will suppress the printing and punching of this output.

12) Number of Times Regression is to be Done With Random Selection of Terms

MODE:

TYPICAL VALUES: 1-4

COLUMN: 12

PAR. NUME: NORAND

Under normal operation, the regression analysis chooses, from the set of terms not yet in the predicting equation, the locally best term (i. e. with the highest F-level) tests it and, if successful, enters it into the equation.

However, there is the possibility of two or more terms, each of whose F-level is not quite as high as the best term, but whose combined effect better describes the data than does the single "locally best" term. Hence setting this parameter to a positive integer n will cause the regression to repeat itself n times randomly choosing terms with high F-levels on a integrated basis, and saving the best trial result.

The two parameters that might serve to indicate which trial was better are the coefficient of determination and the standard error of the dependent variable. The standard error of the dependent variable is too greatly influenced by large deviations of relatively few data points and makes a poor "goodness of fit" test. Generally, standard error will be better (i. e. lower) if the coefficient of determination gets better (i. e. higher). Therefore, the measure of which trial result is better is selected on the basis of the change in the coefficient of determination. The "best" result is that one with the largest coefficient of determination.

13) Learning Deck Printed and Punched Output Option

MODE: Integer

RANGE: 0, 1

COLUMN: 13

PAR. NAME: IFPCH

A numeric one suppresses the printing and punching of the final status of the selector arrays and the terms, both of which comprise the experience to be fed into future runs of similar data.

14) Learning Arrays After Each Pass

MODE: Integer

COLUMNS: 14

PAR. NAME: IFLRN

An integer one suppresses the printing; blank or zero allows printing. The learning arrays will be printed after the last pass depending upon the value of IFPCH and will occur independently of this IFLRN.

15) Number of Interactions

MODE: Integer

STD. VALUE: 3

COLUMNS: 15 - 18

PAR. NAME: NOINTR

This integer governs the order of interaction of the terms in the predicting functions.

16) Number of Terms Whose Order of Insertion is Specified by the User

MODE: Integer

RANGE: 0- numbers of terms tried at each solution pass

COLUMNS: 19 - 23

PAR. NAME: NOINIT

A non-zero value forces complete control of the order of insertion of terms, by the user.

In general, this can be done safely and properly only when the user also controls the definitions of the terms to be generated. The effect is to cause the insertion of terms, in the order specified, whether significant or not until the complete set (as specified) has been inserted.

At this point, normal regression analysis is allowed to evaluate the situation and remove any terms found to be below the specified significant level.

The control allows the creation of a multiple term relation (perhaps suggested by theory) in which the individual terms are not as significant as the combination.

17) Number of Terms Initially Defined by User

MODE: Integer

RANGE: 0 - number of terms tried at each solution pass

COLUMNS: 24 - 28

PAR. NAME: NOINT

Defined terms under this control will be used subject to the statistical analysis of the program unless overridden by control parameter (16). If less than the total terms tried at each solution pass are defined by the user, the program will attempt to generate enough new terms to satisfy that limit.

18) Parameter Controlling the Type of Regression Analysis Executed by the Program

MODE: Integer

RANGE: -1, 0, +1

STD. VALUE: -1

COLUMNS: 29 - 33

PAR. NAME: IFCNST

(A) If greater than zero, the data is treated with respect to the coordinate axes and the constant term is always surpressed to zero.

(B) If equal to zero, the data is treated with respect to a set of axes translated to the means of the variables. The constant term is not surpressed.

(C) If less than zero, the data is treated as in part (A) but the constant term is not surpressed. The constant term is treated just like every other term, except that the constant is always inserted as the first term in the relation and held until the next term is tried.

After this point, all constraints are removed.

Type A - Most useful when other information dictates a zero constant.

Type B - Most useful when dealing with data that tends to group itself about the means (biological and sociological problems).

Type C - Most useful in dealing with physical data.

19) Weighted Data Parameter

MODE: Integer

RANGE: 0, 1

COLUMNS: 34

PAR. NAME: IFWT

If data is all of unit weight, set this parameter equal to zero or leave column blank; if data is weighted individually, set the parameter equal to one.

If the parameter is one, each set of data must carry its weight.

20) Extra Format Specification Parameter

MODE: Integer

RANGE: 1 - 9 (never punch a zero)

STD. VALUE: 1

COLUMNS: 35 - 38

PAR. NAME: NUMCDS

If more than 1 and up to 9 format cards are needed to specify the format for the data deck, place the total number of format cards used in these columns. A zero punched here is an error; however, a one will be assumed by the program if these columns are left blank.

21) Problem Number

MODE: Integer

RANGE: MODULO 32768

STD. VALUE: 1

COLUMNS: 39 - 43

PAR. NAME: NOPROB

22) Output Function Name

MODE: Binary Coded Decimal

RANGE: 6 alpha-numeric characters the first of which must be alphabetic

STD. VALUE: Y Value

COLUMNS: 44 - 49

PAR. NAME: FNAME

This parameter is the name assigned to the output external function. The rules for allowable function names are those of the MAD translator (or FORTRAN or both) depending on the value of IFOUT (parameter 11).

23) Previous Experience Parameter

MODE: Integer

RANGE: 0, 1

COLUMNS: 50, 51

PAR. NAME: IFTRWT

If the parameter is equal to one, the program assumes the accumulated learning deck is present. If the accumulated learning deck is present, the user must make certain that any special functions suggested on that previous run that punched the learning deck, are again included in that same order.

24) Number Of Special Functions

MODE: Integer

RANGE: 0 - number of functions to be considered for each independent variable

COLUMNS: 52, 53

PAR. NAME: NOSPFN

When set to zero, standard PFNCT operation giving integer powers and roots and their reciprocals, is assumed. If the user wishes to suggest other special functions such as (in MAD notation) SIN., ATAN., ELOG. or any other function for which there is an evaluation routine available. This parameter is set to the total number of special functions suggested.

Special Functions

The user, upon observing past runs or from physical theory or intuition, might wish to make other functions besides integer powers, roots, and reciprocals available to the program.

This can be done in the following manner:

1. Set the control parameter NOSPFN (control Card #3) equal to the number of special functions suggested.

2. Include a special function card before the data format card (s), listing the functions by their proper name as they would appear in a MAD calling statement, calling on the subroutine that evaluates them (i. e. include the suffixing dots (periods) required by the MAD translator). List these names consecutively in fields of seven columns starting in column one and not extending beyond column 70. Columns 71 - 80 may be used for identification. For example, if the user wishes to make the sine and arc tangent function available to the program, as well as a function he has supplied called FUNCT., this card would have SIN. in column 1 - 7, ATAN. in columns 8 - 14, and FUNCT. in columns 15 - 21.

3. Include a subroutine to evaluate any functions suggested which are not in the system library.

   For example, consider the function FUNCT. which the user wishes to define as (cos (X_1))* (loge (X_1)) and supply to the program. His evaluation routine might be of the following form.

```
$ COMPILE MAD

        EXTERNAL FUNCTION (X1)

        ENTRY TO FUNCT.

        FUNCTION RETURN (COS. (X1))*(ELOG. (X1))

        END OF FUNCTION
```

   These subroutines must be placed before the binary deck (before the $BINARY specification card)

4. Include a subroutine exactly as follows:

```
$ COMPILE MAD

        EXTERNAL FUNCTION

        ENTRY TO DATA.

        EXECUTE LIST. (V)

        VECTOR VALUES V =—, —, —

        FUNCTION RETURN

        END OF FUNCTION
```

The sole purpose of this subroutine is to get the special function evaluation subroutines loaded into core. The function names must appear in the VECTOR VALUES statement in the same order and form that they appeared on the data card in (2).

For example:

VECTOR VALUES V = SIN., COS., ELOG.

Fourth Control Card: Learning Control

The user may, at this stage in the development of artificial intelligence programs, control some of the characteristics of the learning mechanism. Use of the external function structure for the program allows fairly easy modification of the various parts of the program. With the "standard learning mechanism" as it is now used, data is accumulated concerning three kinds of selections.

1) Order of Interaction
2) Variables Entering Interaction
3) Functions of the Variables

A term is generated by selecting interaction order, next the variable to be concerned in the interaction and finally the functions of the variables selected. The term is the cross product of the functions of the variables selected. The program must "learn" which interactions are most useful in explaining the data, which variables are most useful, and which functions of those variables are most useful. The program "learns" by trying to use terms selected by the program to explain the data. If the mechanism has selected a term which is supported by the data and retained by the regression analysis, the mechanism that selected that term is modified so as to be more likely to select a term of a similar character. On the other hand, if a term is not supported by the data and is, thus, of no apparent utility in the equation it is cast out and the mechanism is adjusted to be less likely to select terms of similar character. Since the probability of selection of any component of any allowed term should be bounded positive, the program uses a "half-life" constant to modify the probabilities. In this way, the relative probability of any term may be made arbitrarily small but remains positive.

1) Number of Constants

MODE: Integer

RANGE: 3 - 12

STD. VALUE: 3

COLUMNS: 1 - 5

PAR. NAME: NOGRDS

The standard mechanism uses three constants. If the mechanism is modified to require more constants, succeeding cards (up to 2) are of format (E 21.8, 3E16.8). The format of the first card is (15, 4E16.8).

2) Half Life Of Interaction Selector

MODE: Floating Point

RANGE: See * below

STD. VALUE: 3.0E00

COLUMNS: 6 - 21

PAR. NAME: Grades (1)

If the standard value of 3.0E00 is used, three consecutive successes will double the present probability (or conversely, three consecutive failures results in a halving of the present probability).

3) Half Life Of Variable Selector

MODE: Floating Point

RANGE: See * below

STD. VALUE: 3.0E00

COLUMNS: 22 - 37

PAR. NAME: Grades (2)

4) Half Life Of Function Selector

MODE: Floating Point

RANGE: See * below

STD. VALUE: 1.5E00

COLUMNS: 38 - 55

PAR. NAME: GRADES (3)

* Here 1.5E000 is used since any function may be used relatively infrequently and it is somewhat desirable to take more powerful action on each encounter.

A great deal of work remains to be done in exploring "learning" mechanisms. It should be observed that as the constants are made larger, the mechanism "learns" more slowly. In fact, for very large values of the constants the mechanism is essentially deactivated. Very small values of the constants, on the other hand, may cause wildly erratic behavior of the mechanism since each encounter so strongly distorts the relative probabilities.

Ordered Term Insertion Card(s)

If the parameter (16) of theThird Control Card is non-zero, the user must supply a set of cards to define the order in which terms are to be inserted. This allows an arbitrary equation to be generated without regard to the statistical analysis after which the statistical analysis may be used to discard those terms that are not sufficiently important to meet the deletion error criterion. If a theoretical relation is available for which a study is being made to determine how the relation may be improved, this feature may be useful. Otherwise, one must assume the risk that some of the theoretical terms will be displaced in the search. The user must be aware that the use of these term order cards is a severe constraint on the analysis and treat the results accordingly.

The format is 14I5. Each five columns contains a integer whose value is the number of a term to be inserted. The first number is the first term to be inserted, the second number is the second term and so on. For example, if parameter (16) on the Third Control Card were three and column five on the Ordered Term Insertion Care were six, column ten were three and column fifteen were one, the effect would be to insert term six, then term three and then term one after which the Stepwise Regression Program would examine the equation to be sure that these terms meet the deletion error criterion. If any of these terms fail the test they will be discarded. When all of the terms in the equation meet the deletion error test, the remaining terms not yet in the equation will be tested for insertion. From this point on the standard analysis is followed:

Data Deck Preparation

1. Format Specification Card

Since the data may come from various sources, the data deck allows the data format to be specified at execution time. This is done

by using a standard FORTRAN format statement beginning with the word FORMAT (beginning in column seven and ending in column thirteen, followed by any allowable format specification that can be placed on one card and terminating with a ")" right parenthesis in or before column 72. For example, the following format statements would be acceptable:

```
Column
   7
   FORMAT (5F10.2, E16. 8)
                or
   FORMAT (4E16. 7,  F10. 1/4E15. 8)
```

This card must immediately precede the data deck, and is known as the Format Specification Card.

2. Data Cards

Following this card are the data cards. Arbitrary formats are allowed as described above. The data must be listed for each observation in the following order however. (All values are floating point numbers).

1) Observation Number. There must be a positive observation number for every observation. Run number one must appear once and only once.

2) Independent Variables. These values are listed in order following the observation number. The values must correspond to one observation group.

3) Dependent Variable. The variable whose value is to be predicted must follow the predictor or independent variables.

4) Weight of this Observation group. The weight of the group may be specified or can be assumed to be unity depending on the parameter (11) of Problem Control Card.

3. End of Data Card

The actual data is then followed by a complete blank data set which acts as a termination for the data. If any Observation Number is blank or less than or equal to zero, the data input is terminated at that point. Therefore, the user must take care in preparing the data deck so that the entire set of data will be read into machine storage.

The program automatically counts the weighted data sets to establish the degrees of freedom for the analysis. In this way, new data can be added to the data deck and/or old data can be deleted very easily.

The Accumulated Learning Deck

Whenever a multiple independent variable problem occurs in which a large number of functions are allowed for each independent variable and interactions of all orders are admitted, the result is the generation of a very large set of possible terms that may appear in a predicting equation. Since the most desirable equation consists of a "minimal" set of these terms comprising those terms most significant in explaining the dependent variable behavior, it becomes apparent that the analysis must usually perform a selection process while dealing with a segment of the entire set of terms at each encounter.

If it is possible to verify the validity of terms independently from their method of initial selection then it becomes feasible to allow the machine to select the terms using some heuristic method. The terms so selected will not always be the correct ones or even the "best" ones although the method of selection should certainly tend to operate in this way. The important point to observe is that the validity of the term is tested by the regression analysis independently of the selection and the regression analysis is, therefore, not affected in any way by the heuristic method of selection. Because of this, the heuristic term selection method is free to select terms using any convenient scale for choosing the terms. If the terms so selected are shown to have validity by the regression analysis then the heuristic method that selected the valid term is modified so as to be more likely to select similar terms. A converse action occurs whenever the term is shown to be invalid.

At the completion of each solution pass the current status of the selector mechanism is represented by a set of values which give:

1) The relative probability of each Interaction Order.
2) The relative probability of each Independent Variable.
3) The relative probability of each function of each variable.

Whenever no accumulated learning deck is available, parameter (12) of the problem control parameter card is set equal to zero. The result is that the program will then assign equal unit relative probability to all interactions, variables and functions of variables.

If previous encounters with similar problems have occurred, however, the program has already had "experience" with a similar problem and

can be allowed to take advantage of these encounters by providing the accumulated learning deck that was automatically produced at the conclusion of the former problem together with the new problem data. If the user desires to transmit this information to the program, parameter (12) of the problem control parameter card is set equal to one and the accumulated learning deck is placed after the data deck.

The user can also suggest his own experience to the program by preparing an accumulated learning deck. The format is 5E14. 7. The relative probabilities are inserted in the following order:

1) Relative Probabilities for Interactions from first order to the maximum order for the problem.

2) The sum of the preceeding probabilities (1).

3) Relative Probabilities for Independent Variables, from the first to the last in the same order as they appear in the data deck.

4) The sum of the preceeding probabilities (3).

5) Relative probabilities for each function of the first variable followed by the sum of these probabilities.

6) Relative probabilities as in (5) for the second, third, etc. variables.

The preceeding items are punched successively in the available fields as specified by the format. No blank fields are permitted between groups since every field in interpreted consecutively.

The accumulated learning produced by the machine program has each relative probability normalized so that the mean relative probability is unity. In this way, a problem may be easily expanded to more variables, functions, etc. and still retain previous "experience" by making all new entries of unit value.

Because of the independent regression analysis of the terms chosen from the accumulated learning it must be emphasized that this mechanism cannot force the adoption of incorrect terms. Rather, such an incorrect set of "experience" would be modified progressively by the program. If the "experience" supplied is valid for the current problem the result is to speed the generation of the desired equation but invalid "experience" can only temporarily delay this generation.

In general, if good experience is available from previous similar problems or from the user's background the user is strongly advised to make use of it.

Initial Pass Terms Deck

The user may suggest any initial terms that may be desired for the first pass. If the suggested terms stem from theoretical considerations and the theory is in agreement with the data, such a suggestion will speed the generation of the predicting equation by insuring an early treatment of likely terms. Any number of terms may be given initially up to the total number of terms allowed for each pass. The number of terms to be so defined by the user is given by the parameter (17) on control card number three.

At the end of each problem and immediately following the production of the accumulated learning deck, the program produces a set of terms to begin the next encounter with the problem. If the problem is continued later, these terms may be supplied by simply including these cards following the accumulated learning deck and setting parameter (17) control card three.

If the user wishes to suggest terms the procedure is the following:

(The card format is 14F5.0)

1) Produce a card (or cards, if sufficient variables are present) as described below for each term desired.

2) Treat each consecutive field in the above format specification as a one to one correspondence with the independent variables in the problem.

   2A) Insert the appropriate exponent corresponding to the particular function that is desired.

   2B) Leave blank (or zero) every variable field not associated with the term.

3) Insert the interaction order in the field immediately following the last variable field.

For example:

Suppose the user is dealing with two independent variables and the "standard" definition of function and desires to form the term: X(1). P. 3 X(2). P. - 1/2

The term is specified by punching a three (3. 0) in column five, a negative one-half (-0. 5) in column ten, and a two (2. 0) in column fifteen. The two in column fifteen declares the term to be a second order interaction and thus produces the desired multiplication of the two components of the term considered above.

```
$ COMPILE FORTRAN,PRINT OBJECT,PUNCH OBJECT                    PGEN0000 CORE7
C
C
C  CORE 7 -- PGEN
C    (1) GENERATES THE FINAL EQUATION.
C    (2) CALLED FROM CORE 3 AND CORE 4.
C  PROCESS -- PRINTS AND PUNCHES THE SPECIFICATION CARDS, DIMENSION, AND
C        IF APPLICABLE, THE INTEGER DECLARATION.
C  CTERM -- PRINTS AND PUNCHES THE CONSTANT FOR EACH TERM.
C  GENTRM -- PRINTS AND PUNCHES THE COMPONENTS OF EACH TERM (FOR FORTRAN
C        PROGRAMS).
C  GTERM -- PRINTS AND PUNCHES THE COMPONENTS OF EACH TERM ( FOR MAD
C        PROGRAMS).
C  SUMEQN --
C    (1) PRINTS AND PUNCHES STATEMENTS WHICH WILL SUM THE EQUATION.
C    (2) PRINTS AND PUNCHES THE TERMINATING STATEMENES OF THE PROGRAM.
C  CORE 1 -- THE STARTER PROGRAM
C    (1) STARTS NEW PROBLEMS.
C    (2) PUNCHES THE LEARNING ARRAYS AND TERMS ARRAY IF REQUESTED.
C
C
      SUBROUTINE CORE7
       COMMON NO,J1,ERASE,ICOUNT,DNNY,IFOUT,ERAS,NOPASK,
     1NOINKP,EERAS,NBEGIN,DDMMYY,ITAPE9,DM,NORAND,FNAME,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
     7  MAX,K,NOENT,FLEVEL,CNST,FLEVL,TERMS,DMY,FUNC,NOSPFN
      DIMENSION ERASE(7),ERAS(3),EERAS(2),DDMMYY(7),TERMS(60,60),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2  DATA(60),Z(60),FUNC(60),DMY(1000) ,
     6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
      EQUIVALENCE(DATA ,Z)
          EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
      IF (NBEGIN) 712,711,712
711   WRITE OUTPUT TAPE 6,3333
3333  FORMAT(60HONO TERMS HAVE BEEN ENTERED INTO THE REGRESSION EQUATION
     -.                )
      GO TO 22
712   IF(NORAND) 713,713,714
713   IF(NOIN) 21,21,715
715   NIN = NOIN
      GO TO 717
714   IF(NOINKP) 21,21,92
92    NIN = NOINKP
717   CONTINUE
      IF(CNST)1,2,1
   1  NIN =NIN+1
2     IF(IFOUT-2)400,400,21
400   IF(IFOUT-1)401,402,401
401   IFFOUT=0
      GO TO 300
402   IFFOUT =1
 300  CALL PROCES(FNAME,NOIND,NIN,IFFOUT)
```

```
      I=1
      IF(CNST)3,4,3
    3 CALL CTERM(I,CNST)
      I=I+1
    4 DO 20 I1=I,NIN
      I3 = I1 - I + 1
      CALL CTERM(I1,COEN(I3))
    5 IF(TERMS(I3,60))8,20,8
    8 J1=TERMS(I3,60)
      J2=0
      DO 11 J=1,J1
   10 J2=J2+1
      IF(TERMS(I3,J2))9,10,9
    9 A3=TERMS(I3,J2)
      J3=A3
      J3NFNS=J3-NOFNCT+NOSPFN
      IF(J3NFNS)332,332,331
331   FUNCT=FUNC(J3NFNS)
      IN1=1
      GO TO 333
332   FUNCT = A3
      IN1=0
333   IF(IFFOUT)350,350,250
250   CALL GENTRM(I1,J2,FUNCT,IN1)
      GO TO 11
350   CALL GTERM(I1,J2,FUNCT,IN1)
   11 CONTINUE
   20 CONTINUE
      CALL SUMEQN(FNAME,NIN,IFFOUT)
      IF(IFOUT-2)21,406,21
406   IFFOUT=1
      IFOUT=3
      GO TO 300
   21 CONTINUE
   22 CONTINUE
       NOEXIT=2
23    CALL CORE1(NIN)
           RETURN
      END                                                          *
```

```
$ COMPILE FORTRAN,PRINT OBJECT,PUNCH OBJECT                    START100 CORE1
C
C
C  CORE 1 -- THE STARTER PROGRAM
C    (1) STARTS NEW PROBLEMS.
C    (2) PUNCHES THE LEARNING ARRAYS AND TERMS ARRAY IF REQUESTED.
C  PARAM -- READS IN THE LAST THREE CONTROL CARDS AND ESTABLISHES
C        STANDARD VALUES FOR COMMON VARIABLES.
C  DATARD -- READS IN THE NAMES OF THE EXTERNALLY SUPPLIED FUNCTIONS.
C
C  DATAIN -- READS IN THE FORMAT FOR THE DATA AND THE DATA.
C
C  RDTRWT -- READS IN THE TERM WEIGHTS IF SUPPLIED BY THE USER.
C
C  CMTRWT -- COMPUTES THE TERM WEIGHTS IF NOT SUPPLIED BY USER.
C
C  TRMCHK -- CHECKS THE TERMS IN THE EQUATION TO INSURE INDEPENDENCE.
C  PKTRM -- PICKS NEW TERMS, I.E. IT RANDOMLY PICKS INTERACTION ORDERS,
C        VARIABLES, FUNCTIONS, AND WHEN APPLICABLE, THE EXTERNAL
C        FUNCTIONS TO FILL IN THE TERMS ARRAY.
C  CORE4 -- THE EDITOR PROGRAM.
C    (1) EVALUATES THE EQUATION AND CHECKS FOR COMPATIBILITY WITH THE
C        MACHINE WORD SIZE.
C    (2) EVALUATES THE EQUATION FOR ALL DATA SETS.
C
C
C
      SUBROUTINE CORE1 (NNI)
      COMMON I1,J1,NOCNT,ERASE,NOINTR,     IFPCH,IFSMPL,ERAS,FNAME,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTONT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     8ARRAY3,ARRAY2,ARRAY1,DMYXXX,TERMS,DUMMY,FUNC,NOSPFN
      DIMENSION ERASE(9),ERAS(15),DUMMY(1000),FUNC(60),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60),TERMS(60,60),
     4ARRAY1(60),ARRAY2(60,2),ARRAY3(60,60),DMYXXX(136)
      EQUIVALENCE (DATA,Z)
          EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
C
C
C
      REWIND 3
      IF (LRAM) 21,20,21
   21 IF(NOEXIT-1)22,20,22
22    WRITE OUTPUT TAPE 6,103,NOPROB
  103 FORMAT(12H0PROBLEM NO.I5,25H ... NORMAL TERMINATION  ////)
      IF(IFPCH)200,200,20
200   CONTINUE
300   CALL TAPE1(ITAPE3,NORCD3(1))
      READ TAPE ITAPE3,ARRAY1,ARRAY2,ARRAY3
      PUNCH 101,(ARRAY1(I),I=1,NOIND),ARRAY1(60),(ARRAY2(I,1),I=1,NOIND)
     ,,ARRAY2(60,1),((ARRAY3(I,J),J=1,NOFNCT),ARRAY3(I,60),I=1,NOIND)
  101 FORMAT(5E14.7)
      DO 641 I=1,NNI
```

```
      PUNCH 101,(TERMS(I,J),J=1,NOIND),TERMS(I,60)
641   CONTINUE
   20 NOEXIT=0
      NODATA=0
       LRAM=1
      DO 30I=1,60
      DO 30 J=1,60
   30 TERMS(I,J)=0.
C  THE FIRST CONTROL CARD......
C          READ AND PRINT HEADING
      READ INPUT TAPE 7,102
102   FORMAT(72H
     -                  )
      WRITE OUTPUT TAPE 6,102
      DOIN = PARAM(0)
      IF(NOSPFN)114,114,112
112   NPFN=NOSPFN-1
      DOIN = DATARD(NPFN,FUNC) + DOIN
      WRITE OUTPUT TAPE 6,620,NOSPFN,((I,FUNC(I),),I=1,NOSPFN)
620   FORMAT(10H6THERE ARE,I3,38H EXTERNALLY SUPPLIED SPECIAL FUNCTIONS/
     1/4(13H FUNCTION NO.,I3,4H IS ,A6,5X)/)
114   CALL DATAIN
      IF(IFTRWT)1,2,1
    1 CALL RDTRWT(ARRAY1,ARRAY2,ARRAY3,ITAPE3,NORCD3(1),NOIND,NOFNCT)
      GO TO 3
    2 CALL CMTRWT
    3 NOCNT=0
      IF(IFCNST)4,7,7
    7 IF(NOINT)5,5,10
   10 J=1
   11 K=NOINT+J-1
      DO 6I1=J,K
      READ INPUT TAPE 7,101,(TERMS(I1,I),I=1,NOIND),TERMS(I1,60)
C  READS IN THE TERMS IF INITALLY SUPPLIED BY THE USER.
    6 CALL TRMCHK(N1,NOCNT,TERMS,NOIND,NOSTRT)
    5 J1=NOCNT+1
      NOPASS=1
      IF(J1-NOTRMS)12,12,13
12    ISTL = 1
      DO 8 I1=J1,NOTRMS
    9 CALL PKTRM(TERMS,LRAM,ARRAY1,ARRAY2,ARRAY3,NOIND,NOFNCT)
      CALL TRMCHK(N1,NOCNT,TERMS,NOIND,NOSTRT)
       ISTL=ISTL+1
      IF (ISTL-1000) 31,31,32
32    NOTRMS=I1-1
      WRITE OUTPUT TAPE 6,110, NOTRMS
110    FORMAT (41HOSELECTOR MECHANISM REDUCED NO. TERMS TO  ,I5)
      GO TO 13
31    GO TO (9,8),N1
    8 CONTINUE
13    IF (DOIN) 20,14,20
14    CALL CORE4
          RETURN
    4 CALL TRMCHK(N1,NOCNT,TERMS,NOIND,NOSTRT)
      J=2
      IF(NOINT)5,5,11
      END                                                              *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          VARSRT00
C      VARSRT COMBINED WITH VINSRT. ALLOWS S.O. OR
C      TERM INSERTION, AS DESIRED.
       SUBROUTINE VARSRT
       COMMON NO,NSW,NVP,I,I1,ERASE,ICOUNT,ERAS,
      1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
      2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
      3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
      4DIT,NCRGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
      5DEX,X,Z,NOIN,NOEXIT,
      6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
      7MAX,K,NOENT,FLEVEL,CNST,FLEVL
       DIMENSION ERASE(4),ERAS(21),FLVMAX(61),IVEC(60),
      2DATA(60),Z(60)          ,
      1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
      6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
       EQUIVALENCE(DATA,Z)
       EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
       IFRAND=1
       IF(NINIT)1,2,1
     1 NSW=2
       NUP=(NOINIT-NINIT)+1
     3 VMAX=0.
       VMIN=0.
       NOIN=0
       FLVMAX(61)=0.
       ITERA =1
       FLVIN=FLVL(PRBIN,DEFR)
301    DO 4 I=1,NUP
       GO TO (5,6),NSW
     5 I1 = I
       GO TO 7
     6 I1=INVAR(I)
     7 IF(ARRAY5(I1,I1)-TOL)8,9,9
8      IF(ARRAY5(I1,I1)+TOL)10,41,41
41     ARRAY5(I1,I1)=0.
       GO TO 4
    10 WRITE OUTPUT TAPE 6,100,I1,I1,ARRAY5(I1,I1)
   100 FORMAT (18H ERROR *** ARRAY5(I2,1H,I2,3H) =E17.9,15H, TOO NEGATIVE
      -.)
       R=0.
       N=1
200    RETURN
     2 NSW=1
       NUP=NCTRMS
       GO TO 3
     9 VAR=(ARRAY5(I1,NOZ)*ARRAY5(NOZ,I1))/ARRAY5(I1,I1)
       IF(INDEX(I1))11,12,11
11     NOIN=NOIN+1
       COEN(NOIN)=ARRAY5(I1,NOZ)*SIGMA(NOZ)/SIGMA(I1)
       SIGMCO(NOIN)=(SIGY/SIGMA(I1))*SQRT (ARRAY5(I1,I1))
       GO TO (13,14),NSW
13     IF(VMIN)15,16,16
15     IF(VAR-VMIN)14,14,16
    16 VMIN=VAR
       NOMIN=I1
    14 FLEVL(NOIN)=VAR*DEFR/ARRAY5(NOZ,NOZ)
       GO TO 4
12     VAR=ABSF(VAR)
```

```
      GO TO (120,18),NSW
120   IF(ICOUNT)17,17,870
   17 IF (VAR-VMAX)4,4,18
   18 VMAX=VAR
      NOMAX=I1
      GO TO 4
 870  FLVMAX(ITERA)=VAR*DEFR/(ARRAY5(NOZ,NOZ)-VAR)
      IF (FLVMAX(ITERA)-FLVIN)4,850,850
 850  IVEC(ITERA)=I1
      FLVMAX(61)=FLVMAX(61)+FLVMAX(ITERA)
      ITERA = ITERA +1
    4 CONTINUE
      N=3
      IF (ICOUNT)200,200,801
801   ZERO=0.
      IF(FLVMAX(61)) 869,869,868
869   NO =1
      FLEVEL=0.
      GO TO 200
868   CONTINUE
      NO=0
      FSPOT=FLVMAX(61)*RANDOM(ZERO)
      HOLD=0.
      DO 810 ITERA = 1,60
      HOLD =HOLD+FLVMAX(ITERA)
      IF(HOLD-FSPOT)810,811,811
 810  CONTINUE
 811  I1=IVEC(ITERA)
      VMAX    =(ARRAY5(I1,NOZ)*ARRAY5(NOZ,I1))/ARRAY5(I1,I1)
      NOMAX=I1
      FLEVEL =FLVMAX(ITERA)
      EFIN=FLVIN
      GO TO 200
       END                                                          *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          MATRAN00
C      MATRIX TRANSFORMATION ROUTINE.
       SUBROUTINE MATRAN
       COMMON NO,I,J,ERASE,
      1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
      2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
      3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
      4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
      5DEX,X,Z,NOIN,NOEXIT,
      6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
      7MAX,K,NOENT,FLEVEL,CNST,FLEVL
       DIMENSION ERASE(28),
      1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
      2DATA(60),Z(60)          ,
      6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
       EQUIVALENCE (DATA,Z)
       EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
       IF(K)1,1,2
     1 WRITE OUTPUT TAPE 6,100,K
   100 FORMAT (22H ERROR *** ILLEGAL K =I4)
       CALL CORE1
     2 DO 3 I=1,NOZ
       IF (K - I) 4,3,4
4      DO 5 J=1,NOZ
       IF (J - K) 18,5,18
18     ARRAY5(I,J) = ARRAY5(I,J)-ARRAY5(I,K)*ARRAY5(K,J)/ARRAY5(K,K)
     5 CONTINUE
     3 CONTINUE
       DO 7 I=1,NOZ
       IF(I-K)8,7,8
8      ARRAY5(I,K) = -ARRAY5(I,K)/ARRAY5(K,K)
       ARRAY5(K,I)=ARRAY5(K,I)/ARRAY5(K,K)
     7 CONTINUE
       ARRAY5(K,K)=1./ARRAY5(K,K)
       WRITE OUTPUT TAPE6,102
       CALL PRINT2(ARRAY5,NOZ)
102    FORMAT(1H0,42(1H ),H1TRANSFORMED MATRIX1//)
       RETURN
        END                                                                *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          GRADER00
C       GRADER ROUTINE USING HALF-LIFE VALUES.
C       N=1, IF TERM UNSUCCESSFUL, N=2 IF TERM SUCCESSFUL.
        SUBROUTINE GRADER(A1,A2,A3,TRM,NOTRM,NOV,FIN,N,GRDS,NOPROB,NOGRDS)
        COMMON B1,NO
        DIMENSION A1(60),A2(60,2),A3(60,60),TRM(60,60),GRDS(12),FACTOR(6)
       1,B1(180)
        IF (NOGRDS) 1,2,2
1       NOGRDS = - NOGRDS
        DO 3 I=1,3
        FACTOR(2*I-1) = .5**(1./GRDS(I))
    3   FACTOR(2*I) = 1./FACTOR(2*I-1)
    2   IF(TRM(NO,60))9,5,4
9       TRM(NO,60)=-TRM(NO,60)
    4   I1=TRM(NO,60)
        A1(I1)=A1(I1)*FACTOR(N)
        II=0
        DO 6 I1=1,NOV
        X=TRM(NO,I1)
        IF (X-FIN) 11,11,10
10      I2 = X
        GO TO 7
11      CONTINUE
        IF(X) 12,6,13
C           IF THE EXPONENT IS POSITIVE ADD1, OTHERWISE ADD 2.  IF THE
12      X=ABSF(X)
        NEG=2
        GO TO 14
13      NEG=1
14      IF(X-1.) 16,15,17
C           EXPONENT IS AN INTEGER, SUB. 2, OTHERWISE ADD 0.
15      I2=NEG
        GO TO 7
16      INTEGR = 0
        X=1./X
        GO TO 18
17      INTEGR = -2
18      I2=X
        K=X+.5
        IF(K-I2) 5,21,20
20      I2=K
21      I2 = 4*(I2-1) + NEG + INTEGR
C           NUMBER ASSOCIATED WITH THE EXPONENT IS GIVEN BY
C           4*(EXPONENT - 1) + EXTRA NUMBERS IF POSITIVE OR NEG AND IF
C           AN INTEGER OR A FRACTION.
    7   A2(I1,1)=A2(I1,1)*FACTOR(N+2)
        A3(I1,I2)=A3(I1,I2)*FACTOR(N+4)
    6   CONTINUE
    8   RETURN
    5   WRITE OUTPUT TAPE 6,100,NOPROB,(I,TRM(NO,I),I=1,60)
  100   FORMAT (42HOERROR *** GRADER ENCOUNTERS ILLEGAL TERM./12H PROBLEM
       -NO.I5/4(8H   TERM(I2,3H) =E15.7))
        CALL CORE1
         END                                                              *
```

```
$COMPILE MAD      ,PRINT OBJECT, PUNCH OBJECT                          DUMMY000
          EXTERNAL FUNCTION
          ENTRY TO DATA.
          PRINT COMMENT$6****ERROR YOU SUGGESTED USAGE OF SPECIAL  FUNC
         1TIONS AND FORGOT THE DUMMY SUBROUTINES$
          EXECUTE CORE1.
          FUNCTION RETURN
          END OF FUNCTION                                                    *
$ COMPILE FORTRAN,PRINT OBJECT,PUNCH OBJECT                          EDITR000 CORE4
C
C
C  CORE4 -- THE EDITOR PROGRAM.
C    (1) CHECKS EACH TERM FOR COMPATIBILITY WITH THE MACHINE WORD SIZE.
C        MACHINE WORD SIZE.
C    (2) EVALUATES EACH TERM FOR ALL DATA SETS.
C    (3) CALLED FROM CORE 1 AND CORE3.
C  TAPE1 -- TAPE1(I,J) SPACES TAPE I BY J RECORDS.
C  ZFNCT -- CONTROLS THE EVALUATION OF EACH TERM , USING ONE DATA SET
C        PER EVALUATION OF THE EQUATION ( THE DATA SETS BEING CONTROLED
C        BY THE EDITOR PROGRAM).
C  CORE6 -- CONTROLS THE USE OF REGRESSION AND WINDUP.
C  CORE7 -- (PEGEN) GENERATES THE FINAL EQUATION.
C  CORE3 -- THE STUDENT.
C    (1) CONTROLS THE LEARNING PROCEDURES.
C    (2) REFILS THE TERMS ARRAY.
C    (3) CALLED FROM CORE4 AND WINDUP.
C
C
          SUBROUTINE CORE4
      COMMON NO, ERASE, IFPCH, EERAS,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     9  DMYXXX,TERMS,CRDTA
      DIMENSION ERASE(12), EERAS(17),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60),TERMS(60,60),
     5DMYXXX(3916),CRDTA(1000)
      EQUIVALENCE(DATA,Z)
          EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
      WRITE OUTPUT TAPE 6,101,NOPROB,NOPASS,NOIND,NOTRMS
      IFERR1=0
      CALL TAPE1(ITAPE3,NORCD3(2))
       ISW=0
       ICC=0
      DO 3 I=1,NODATA
C        LOOP EVALUATES THE FUNCTION FOR ALL DATA SETS.
       MAX=ICC+NOVAR+2
       IF (MAX-1000) 901,901,902
901    ICC=ICC+1
       RUN=CRDTA(ICC)
       DO 903 J=1,NOVAR
       ICC=ICC+1
903    X(J)=CRDTA(ICC)
       ICC=ICC+1
```

```
      WHT=CRDTA(ICC)
      GO TC 904
902   IF(ISW) 905,906,905
906   REWIND ITAPE4
      ISW=1
905   READ TAPE ITAPE4,RUN,(X(J),J=1,NOVAR),WHT
C
C       IF THERE ARE MORE THAN 1000 +ATA POINTS (=(NOVAR*2)*NODATA),
C       THE REMAINIIG POINTS ARE ON TAPE 4.
C
904   CONTINUE
      CALL ZFNCT(I,X,NOIND,WHT,Z,TERMS,NOTRMS,NOFNCT,NOZ,IFERR
     -,NOSTRT,IFPRNT,NOPASS,RUN)
      IF (IFERR)4,3,4
    4 WRITE OUTPUT TAPE 6,100,RUN
  100 FORMAT (23H0ERROR *** DATA SET NO.F5.0)
      IFERR1=1
    3 WRITE TAPE ITAPE3,RUN,(Z(I),I=1,NOZ),WHT
      IF(IFERR1)24,20,24
   20 REWIND ITAPE3
      REWIND ITAPE4
      IF (IFCNST)5,6,6
    5 IF(NOPASS-1)7,8,7
    7 NOINIT=1
      GO TO 9
    8 IF(NOINIT)7,7,10
   10 DO 11 I=1,NOINIT
      J1=NOINIT+2-I
      J2=J1-1
   11 INVAR(J1)=INVAR(J2)
      NOINIT=NOINIT+1
    9 INVAR(1)=1
12    CALL CORE6
    6 IF(NOPASS-1)13,12,13
   13 NOINIT=0
      GO TO 12
C       LOOP PUSHES THE GOOD TERMS DOWN INTO THE FIRST N POSITIONS.
24    DO 25 I=1,NOIN
25    INDEX(I)=1
      I=NOIN+1
      DO 26 I=1,NOTRMS
26    INDEX(I)=0
      NOIN = -NOIN
      NOPASS = NOPASS+1
      REWIND ITAPE3
      REWIND ITAPE4
      IF(NOTRYS-NOPASS)30,31,31
30    LRAM = 1.
      NOIN = -NOIN
      IF (IFPCH) 2,2,1
1     CALL PRINT4(1)
2     CALL CORE7
   31 WRITE OUTPUT TAPE6,102,NOPASS,NOPROB
      NOEXIT =2
      CALL CORE3
           RETURN
  102 FORMAT(9H0PASS NO.I5,55H BEGUN (AFTER ERROR DETECTED BY EDITOR) FO
     -R PROBLEM NO.I5////)
  101 FORMAT(15H1EDITOR PROGRAM///12H PROBLEM NO.I5/18H SOLUTION PASS NO
```

```
     -.I5/31H NO. OF INDEPENDENT VARIABLES =I5/21H NO. OF TRIAL TERMS =I
     -5//)
      END                                                                *
```

```
$ASSEMBLE,PUNCH OBJECT                                          STDRD000
        ENTRY   STDRD
        REM
        REM
        REM     SUBROUTINE TO INSERT STANDARD VALUES FOR
        REM     NOFNCT,NOTRYS,NOINTR,IFCNST,NUMCDS,NOTRMS,TOL,PRBIN,
        REM     PRBOUT,CODTRM,NOPROB,FNAME
        REM
        REM
STDRD   SXA     HOLD1,4
        SXA     HOLD2,2
        AXT     12,2
LOOP    CLA*    1,4
        TPL     *+3
        ARS     18
        TZE     BLANK
DECR    TXI     *+1,4,-1
        TIX     LOOP,2,1
HOLD1   AXT     **,4
HOLD2   AXT     **,2
        CLA*    12,4
        SUB     BLNK
        TNZ     *+3
        CLA     LIST
        STO*    12,4
        TRA     12,4
BLANK   CLA     LIST+1,2
        STO*    1,4
        TRA     DECR
        PZE     ,,10
        PZE     ,,3
        PZE     ,,3
        MZE     ,,1
        PZE     ,,1
        PZE     ,,40
        DEC     .0001,.05,.05,.97
        PZE     ,,1
LIST    BCI     1,YVALUE
BLNK    BCI     1,
        END                                                     *
```

```
$ COMPILE FORTRAN,PUNCH OBJECT,PRINT OBJECT                          MAIN0000
      COMMON DMMY,NO,NOGRDS,EFOUT,EFIN,RUN,WHT,IFERR,NVP1,NUMCDS,ICOUNT,
     1IFLRN,IFOUT,NOINTR,IFPCH,NOPASK,NOINKP,BLANK1,BLANK2,BLANK3,BLANK4
     2,BLANK5,BLANK6,BLANK7,BLANK8,BLANK9,BLNK10,BLNK11,ITAPE9,IFRWDA,N
     3ORAND,FNAME,DMMMY,LRAM
      DIMENSION DMMY(180),DMMMY(55)
      ITAPE9=9
       CALL IOHSIZ(1)
       CALL FTRAP
       LRAM=0
      REWIND ITAPE9
      CALL CORE1
           END                                                          *
```

```
$ COMPILE FORTRAN,PUNCH OBJECT,PRINT OBJECT                    ALTRMS00
      FUNCTION   ALTRMS (NOINTR,NOVAR,NOFUN)
5     IF (NOINTR-NOVAR) 2,2,1
1     NOINTR = NOVAR
2     IF (NOINTR) 4,3,4
3    NOINTR =NOVAR
      GO TO 5
4     F=NOFUN
      FI=FCT(NOVAR)
     IF(FI-1.E30)7,8,8
8    ALTRMS=999999.
     GO TO 9
7    ALTRMS=0.
      DO 6 J=1,NOINTR
      I=NOVAR-J
6       ALTRMS=ALTRMS+(FI*F**J)/(FCT(I)*FCT(J))
9    RETURN
      END                                                      *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    PRINT200
C     SPECIAL ARRAY PRINTER ROUTINE NO. 2.
      SUBROUTINE PRINT2(A,N)
      DIMENSION A(61,61)
      NM1=N-1
      WRITE OUTPUT TAPE 6,100,((I,J,A(I,J),J=I,NM1),I=1,NM1)
  100 FORMAT(3(8H   TERM(I2,1OH) VS TERM(I2,3H) =E15.7))
      WRITE OUTPUT TAPE 6,101,(I,A(I,N),I=1,NM1)
  101 FORMAT(3(8H   TERM(I2,15H) VS    Y      =E15.7))
      WRITE OUTPUT TAPE 6,102,A(N,N)
  102 FORMAT(6(1H )19HY      VS    Y      =E15.7)
      RETURN
       END                                                        *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    PRINT300
C       SPECIAL ARRAY PRINTER ROUTINE NO. 3.
        SUBROUTINE PRINT3(A,N)
        DIMENSION A(61)
        NM1 =N-1
        WRITE OUTPUT TAPE 6,100,(I,A(I),I=1,NM1)
  100   FORMAT(4(10H      TERM(I2,3H) = E15.7))
        WRITE OUTPUT TAPE 6,101,A(N)
  101   FORMAT(10(1H ),5HY    = E15.7)
        RETURN
         END                                                     *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          PICKE000
C       PICKE PICKS THE EXPONENTS OR SPECIAL FUNCTION NUMBER.
        SUBROUTINE PICKE(I,A,N,T)
         COMMON B1,NO,B2,NOFNCT,B3,LRAM,DUM,NOSPFN
        DIMENSION T(60,60),A(60,60),B1(180),B2(36),B3(48),DUM(8702)
      4 A(I,60)=0.
        DO 1 J=1,N
      1 A(I,60)=A(I,60)+A(I,J)
        RN = A(I,60)*RANDOM(LRAM)
        T1=0.
        DO 2 J=1,N
        T1=T1+A(I,J)
        IF(RN-T1)3,3,2
      2 CONTINUE
        GO TO 4
3       IF(J-NOFNCT+NOSPFN) 203,203,14
203     IF (XMODF(J,2))33,44,33
C   ODD J FOR INTEGER POWERS AND ROOTS.
C   EVEN J FOR RECIP. INTEGER POWERS AND ROOTS.
     33 K=J/2+1
        K2=1
        GO TO 5
44      K=J/2
        K2=2
      5 K1=K/2+1
        IF(XMODF(K,2))6,7,6
C   ODD K, EXCEPT K=1, INTEGER ROOTS.
C   K = 1, LINEAR TERM OR RECIPROCAL.
C   EVEN K, INTEGER POWERS.
      6 IF(K-1)8,7,8
7       T(NO,I)=K1
        GO TO (12,10),K2
12      RETURN
10      T(NO,I)=-T(NO,I)
        GO TO 12
8       T(NO,I)=1./FLOATF(K1)
        GO TO (12,10),K2
14      T(NO,I)=J
        GO TO 12
         END                                                            *
```

```
$ASSEMBLE,PUNCH OBJECT                                          PROCES00
        REM     MAD AND FORTRAN PROCESSING FUNCTION GENERATOR
PRINT1  CALL .PRINT
PUNCH1  CALL .PUNCH
        ENTRY   PROCES
PROCES  SXA     XRC,4
        SXA     XRB,2
        SXA     XRA,1
        CLA     4,4
        STA     CHECK
        CLA*    4,4
        ARS     18
        STO     S
        CLA     =1
        SUB     S
        STO     N
        CLA*    3,4
        ARS 18
        STO     NIN
        CLA*    2,4
        ARS 18
        STO NOX
        CLA 1,4
        STA FNAME
        STA     FNAMES
        CALL    .PRINT
        STR     SYMTAB,,FRMT2
        STR
        CALL    .PUNCH
        STR     SYMTAB,,FRMT1
        STR
        CALL    .PRINT
        STR     SYMTAB,,FRMT3
        STR
        LXA TWO,2
        CLA PRINT1
RPT     STA OUTPT1
        STA OUTPT2
        STA OUTPT3
        STZ NOCARD
        CLA TWO
        STO VARNO
        LXD NUM1,1
OUTPT1  TSX **,4
        STR     SYMTAB,,FRMT4
CHECK   ZET     **
FNAMES  STR     **
        CLA NOX
        SUB ONE
        TZE RPRN
        ADD     TWO
        STO     NOX
LP1     STR COMMA
        STR X
        STR VARNO
        CLA VARNO
        ADD ONE
        STO VARNO
        SUB NOX
```

```
TEST1   TNX NXTCD,1,1
TEST2   TNZ LP1
RPRN    STR RPAREN
        STR
        CLA*    CHECK
        TNZ     *+5
OUTPT3  TSX **,4
        STR     FRMT6
FNAME   STR **
        STR
        TNX RTRN,2,1
        CLA PUNCH1
        TRA RPT
NXTCD   STO TEMP
        CLA NOCARD
        ADD ONE
        STO NOCARD
        STR
        LXA NUM1,1
OUTPT2  TSX **,4
        STR     SYMTAB,,FRMT5
        STR NOCARD
        CLA TEMP
        TRA TEST2
RTRN    PRINT   FRMT8,NIN,0
        PUNCH   FRMT8,NIN,0
XRC     AXT     **,4
XRB     AXT     **,2
XRA     AXT     **,1
        TRA     5,4
        BCI     1,N
        PZE     N,2
        BCI     1,S
        PZE     S,2
SYMTAB  PZE     4
ONE     PZE 1,0,0
TWO     PZE 2,0,0
NUM1    PZE 15,0,10
NIN     PZE
TEMP    PZE 0,0,0
NOX     PZE 0,0,0
N       PZE
S       PZE
VARNO   PZE 0,0,0
NOCARD  PZE 0,0,0
COMMA   BCD 1,
X       BCD 1X
RPAREN  BCD 1)
FRMT1   BCI ,  ,N,(13H$ COMPILE MAD/),S,(17H$ COMPILE FORTRAN/),14H$ PUNCH
        BCI     *,OBJECT/14H$ PRINT OBJECT*
FRMT2   BCI ,,N,(4H1MAD),S,(H$1FORTRAN$),H$ EXTERNAL FUNCTION STATEMENTS F
        BCI ,OR PREDICTING EQUATION PRODUCED BY LAST REGRESSION STEP$//*
FRMT3   BCI ,,N,(14H $ COMPILE MAD/),S,(18H $ COMPILE FORTRAN/),15H $ PUNC
        BCI     *,H OBJECT/15H $ PRINT OBJECT*
FRMT4   BCI ,S11,,N,(H$EXTERNAL FUNCTION$),S,(H$FUNCTION $C6,),3H(X110(C1,
        BCI ,C1,I2)*
FRMT5   BCI ,S5,,N,(S5,),I1,,S,(S5,),15(C1,C1,I2)*
FRMT6   BCD 7S11,9HENTRY TO C6,1H./S11,9HINTEGER I*
FRMT8   BCD 5S11,12HDIMENSION T(I2,1H)*
        END                                                              *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          TSTLVL00
C       F LEVEL TEST ROUTINE
        SUBROUTINE TSTLVL
        COMMON NO,N1,EFOUT,EFIN,ERASE,
       1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
       2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
       3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
       4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
       5DEX,X,Z,NOIN,NOEXIT,
       6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
       7MAX,K,NOENT,FLEVEL,CNST,FLEVL
        DIMENSION ERASE(27),
       1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
       2DATA(60),Z(60)          ,
       6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
        EQUIVALENCE (DATA,Z)
        EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
        N1=1
        GO TO (1,2,3),N
     1  FLEVEL=VMIN*DEFR/ARRAY5(NOZ,NOZ)
        EFOUT=FLVL(PRBOUT,DEFR)
        IF(EFOUT+FLEVEL)2,2,4
     4  K=NOMIN
        NOENT=0
        INDEX(NOMIN)=0
        GO TO 5
2       VX = ARRAY5(NOZ,NOZ) - VMAX
        IF (VX) 100,7,101
100     IF (TOL + VX) 9,7,7
101     FLEVEL = VMAX * DEFR / VX
        GO TO (6,7),N1
     6  EFIN=FLVL(PRBIN,DEFR)
        IF(EFIN-FLEVEL)7,8,9
     7  K=NOMAX
        NOENT=K
        INDEX(NOMAX)=1
     5  N=4
10      CONTINUE
        RETURN
     8  IF(EFIN)9,9,7
     9  N=1
        GO TO 10
     3  N1=2
        GO TO 2
         END                                                              *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          RDTRWT00
      SUBROUTINE RDTRWT(ARRAY1,ARRAY2,ARRAY3,ITAPE,NORCD,NOVAR,NOFNCT)
C     READ TERM WEIGHT ROUTINE
      DIMENSION ARRAY1(60),ARRAY2(60,2),ARRAY3(60,60)
      READ INPUT TAPE 7,100,(ARRAY1(I),I=1,NOVAR ),ARRAY1(60),(ARRAY2(I,
     -1),I=1,NOVAR),ARRAY2(60,1),((ARRAY3(I,J),J=1,NOFNCT),ARRAY3(I,60),
     -I=1,NOVAR)
  100 FORMAT (5E14.7)
      CALL TAPE1(ITAPE,NORCD)
      WRITE TAPE ITAPE,ARRAY1,ARRAY2,ARRAY3
      RETURN
       END                                                               *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    PKTRM000
C       TERM SELECTOR ROUTINE
        SUBROUTINE PKTRM(TERMS,LRAM,ARRAY1,ARRAY2,ARRAY3,NOVAR,NOFNCT)
        COMMON B1,NO
        DIMENSION TERMS(60,60),ARRAY1(60),ARRAY2(60,2),ARRAY3(60,60)
       1,LRAM(3),B1(180)
        DO 1 I=1,60
      1 TERMS(NO,I)=0.
        TERMS(NO,60)=PICKV(ARRAY1,NOVAR)
        CALL PICKS(TERMS,ARRAY2,ARRAY3,NOVAR,NOFNCT)
        RETURN
         END                                                          *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    TRMCHK00
C       TERM CHECKER
        SUBROUTINE TRMCHK(N1,NOCNT,TERMS,NOVAR,NOSTRT)
        COMMON B1,NO
        DIMENSION TERMS(60,60),B1(180)
        IF(NOCNT)1,1,2
    1   N1=2
        NOCNT=NOCNT+1
    3   RETURN
    2   DO 4 I=1,NOCNT
        IF (TERMS(NO,60)-TERMS(I,60))4,6,4
    6   DO 7 I1=1,NOVAR
        IF (TERMS(NO,I1)-TERMS(I,I1))4,7,4
    7   CONTINUE
        N1=1
        GO TO 3
    4   CONTINUE
        GO TO 1
         END                                                      *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    PICKV000
      FUNCTION PICKV(A,N)
      COMMON B1,NO,ERASE,NOINTR,ERAS,LRAM
      DIMENSION A(60),B1(180),ERASE(11),ERAS(73)
      A(60)=0.
   10 DO 1 I=1,NOINTR
    1 A(60)=A(60)+A(I)
      RN = A(60)*RANDOM(LRAM)
      T1=0.
      DO 2 I=1,NOINTR
      T1=T1+A(I)
      IF (RN-T1)3,3,2
    2 CONTINUE
      GO TO 10
    3 PICKV=I
      RETURN
       END                                                        *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          PICKS000
      SUBROUTINE PICKS(T,A2,A3,NV,NF)
      COMMON B1,NO,B2,LRAM
      DIMENSION T(60,60),A2(60,2),A3(60,60),B1(180),B2(85)
   12 K1=1
      NOPCKS =T(NO,60)
      IF(NV-NOPCKS)1,1,2
    1 T(NO,60)=NV
      K=2
      DO 7 I1=1,NV
      GO TO 8
    7 CONTINUE
      GO TO 9
    2 A2(60,1)=0.
      DO 3 I=1,NV
      A2(60,1)=A2(I,1)+A2(60,1)
    3 A2(I,2)=A2(I,1)
      A2(60,2)=A2(60,1)
      K=1
      DO 4 I=1,NOPCKS
      RN = A2(60,2)*RANDOM(LRAM)
      T1=0.
      DO 5 I1=1,NV
      T1=T1+A2(I1,2)
      IF(RN-T1)6,6,5
    5 CONTINUE
      GO TO (2,11),K1
    6 K1=2
      A2(60,2)=A2(60,2)-A2(I1,2)
      A2(I1,2)=0.
    8 CALL PICKE(I1,A3,NF,T)
      GO TO (4,7),K
    4 CONTINUE
    9 RETURN
   11 DO 13 I=1,59
   13 T(NO,I)=0.
      GO TO 2
      END                                                                *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    PFNCT000
C
C
C  PFNCT --
C    (1) EVALUATES EACH COMPONENT AND PRINTS THE EQUATION.
C    (2) CALLED FROM ZFNCT.
C  STQUO -- I/O ROUTINE WHICH SAVES THE CURRENT CONTENTS OF THE I/O
C        BUFFERS FROM THE PREVIOUS I/O CALL.
C  SPEFUN -- FUNCTION WHICH CONNECTS WITH THE EXTERNALLY DEFINED
C        FUNCTIONS FOR THE FUNCTION EVALUATION.
C
C
      FUNCTION PFNCT(X,I,A,N,JVAR,NOFNCT,IFER )
      COMMON DMYXXX,FUNC,NOSPFN
      DIMENSION X(120),FUNC(60),DMYXXX(8909)
      IFER=0
      J3=A+.5
      GO TO (1,2),JVAR
C
C        JAVAR = 1 IF X REPRESENTS AN INDEPENDENT VARIABLE, = 2 IF X
C        REPRESENTS A DEPENDENT VARIABLE.
C
1     J7=J3-NOFNCT+NOSPFN
C
C        IF J7 IS GREATER THAN ZERO, J7 CORRESPONDS TO AN EXTERNAL
C        FUNCTION NUMBER.
C
      IF (J7) 13,13,204
13    GO TO (203,12),N
203   IF (A-1.0) 3,4,3
4     CALL STQUO
      WRITE OUTPUT TAPE 6,101,I
101   FORMAT(S1, 2HX(,I2,1H))
      GO TO 12
3      CALL STQUO
       WRITE OUTPUT TAPE 6, 100,I,A
100   FORMAT(S1 ,2HX(,I2,6H) ,P, ,S1,F10.5)
12    PFNCT=X(I) ** A
11    RETURN
    2 PFNCT = X(I)
      GO TO (16,11),N
16    CALL STQUO
      WRITE OUTPUT TAPE 6,103,J3,I
       GO TO 11
204   PFNCT=SPEFUN(J7,X,I)
      IF(J7)207,208,208
208   GO TO (205,11),N
205   CALL STQUO
      WRITE OUTPUT TAPE6,104,FUNC(J7),I
104   FORMAT(S1 ,A6,3H(X(,I2,2H)))
      GO TO 11
  103 FORMAT(6HOTERM(I2,6H) = X(I2,22H), DEPENDENT VARIABLE.)
207   J7=-J7
      WRITE OUTPUT TAPE6,110,FUNC(J7),I
110   FORMAT(1H ,A6,41HCANNOT HANDLE THIS COMPUTED VALUE FOR  X(,I3,1H))
      IFER=1
      GO TO 11
       END                                                        *
```

```
$ASSEMBLE, PUNCH OBJECT,PRINT OBJECT                    SPEFUN000
        ENTRY   SPEFUN
        ENTRY   LIST
SPEFUN  SXA     HOLD,4
        SXA     XRB,2
        SXA     XRA,1
        CALL    DATA
LIST    CLA     1,4
        STA     LOC
        LXA     HOLD,4
        CLA*    1,4
        ARS     18
        SUB     =1
        PAX     ,2
        CLA*    3,4
        ARS     18
        SUB     =1
        STO     FARHAD
        CLA     2,4
        SUB     FARHAD
        STA     PAR
LOC     CLA     **,2
        STA     *+1
        TSX     **,4
PAR     PAR     **
        PAR     ERLOC
RTM     LXA     HOLD,4
XRB     AXT     **,2
XRA     AXT     **,1
        TRA     4,4
ERLOC   CLA*    LOC
        SSM
        STO*    LOC
        TRA     RTM
        ZERO    FARHAD,HOLD
        END                                                *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          PRINT400
C
C
C  PRINT4 --
C    (1) PRINTS OUT THE SELECTOR ARRAYS.
C    (2) CALLED FROM CORE3 AND CORE7.
C
C
      SUBROUTINE PRINT4
      COMMON NO,ERASE,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NCRGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     8ARRAY3,ARRAY2,ARRAY1
      DIMENSION ERASE(30),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60)          ,
     4ARRAY1(60),ARRAY2(60,2),ARRAY3(60,60)
      EQUIVALENCE (DATA,Z)
       EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
      WRITE OUTPUT TAPE 6, 99
   99 FORMAT(35H1PRESENT STATUS OF SELECTOR ARRAYS.)
      WRITE OUTPUT TAPE 6,104
  104 FORMAT(18H0INTERACTION ARRAY/1H0,4(29HINTERACTION NO.    WEIGHT
     - ))
      WRITE OUTPUT TAPE 6,100,(I,ARRAY1(I),I=1,NOIND )
  100 FORMAT(4(I8,E21.7))
      WRITE OUTPUT TAPE 6,101,ARRAY1(60)
  101 FORMAT(17H0SUM OF WEIGHTS =E17.7//)
      WRITE OUTPUT TAPE 6,105
  105 FORMAT(15H0VARIABLE ARRAY/1H0,4(29H   VARIABLE NO.    WEIGHT      ))
      WRITE OUTPUT TAPE 6,100,(I,ARRAY2(I,1),I=1,NOIND)
      WRITE OUTPUT TAPE 6,101,ARRAY2(60,1)
      WRITE OUTPUT TAPE 6,106
  106 FORMAT(15H0FUNCTION ARRAY)
      DO 1 I=1,NOIND
      WRITE OUTPUT TAPE 6,103,I
  103 FORMAT(13H0VARIABLE NO.I3/1H0,4(29H   FUNCTION NO.    WEIGHT      ))
      WRITE OUTPUT TAPE 6,100,(J,ARRAY3(I,J),J=1,NOFNCT)
    1 WRITE OUTPUT TAPE 6,101,ARRAY3(I,60)
      RETURN
       END                                                              *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          ZFNCT000
C       ZFNCT SUBROUTINE FOR REGRESSION PLUS LEARNER.
        SUBROUTINE ZFNCT (I   ,X,NOIND,WHT,Z,TRMATX,NOTRMS,NOFNCT,NOZ,IFERR
       -,NOSTRT,IFPRNT,NOPASS,RUN)
        DIMENSION X(120),Z(60),TRMATX(60,60)
        IFERR=0
        NOVAR=NOIND+1
        ASSIGN 32 TO N
        IF(1) 200,200,201
200     GO TO N,(32)
201     CALL SET8(N)
        IF(I-1)1,2,1
      1 N=2
        GO TO 3
      2 N=1
      3 GO TO (4,5),N
      4 WRITE OUTPUT TAPE 6,100,NOPASS
    100 FORMAT (36H TRIAL TERM DEFINITIONS FOR PASS NO.I5)
      5 DO 6 I=1,NOTRMS
        Z(I)=1.
        IF(TRMATX(I,60))6,8,9
      8 GO TO (10,6),N
     10 WRITE OUTPUT TAPE 6,102, I
    102 FORMAT (6H0TERM(I2,23H) = 1.0, CONSTANT TERM.)
        GO TO 6
      9 I1=ABSF(TRMATX(I,60))
        GO  TO (11,12),N
     11 WRITE OUTPUT TAPE 6,103,I,I1
    103 FORMAT (6H0TERM(I2,25H) = INTERACTION OF ORDER I2,43H, WHERE THE C
       -OMPONENTS ARE DEFINED TO BE --)
     12 I2=1
        JVAR=1
        DO 13 J=1,I1
     18 IF(I2-NOIND)14,14,7
     14 IF (TRMATX(I,I2))16,15,16
     15 I2=I2+1
        GO TO 18
     16 A3=TRMATX(I,I2)
        GO TO (19,20),N
     19 WRITE OUTPUT TAPE 6,104,J
    104 FORMAT (1H ,9X ,10HCOMPONENT(I2,3H) =N)
20      Z(I)=Z(I)*PFNCT(X,I2,A3,N,JVAR,NOFNCT,IFER )
        IF (IFER)32,30 ,32
     30 CONTINUE
     13 I2=I2+1
333     IF(Z(I))33,6 ,33
33      IF(ABSF(Z(I))-1.E18)31,34,34
31      IF(1.E-18-ABSF(Z(I)))6 ,34,34
32      WRITE OUTPUT TAPE 6,108,I,J
108     FORMAT(51H0FLOATING POINT TRAP OCCURED WHILE PROCESSING TERM(,I2,
       - 17H)  --  COMPONENT(,I2,2H).)
34      IFERR=1
        TRMATX(I,60)=-ABSF(TRMATX(I,60))
        WRITE OUTPUT TAPE 6,107,I,Z(I)
6       CONTINUE
        JVAR=2
        A3 = NOZ
        Z(NOZ)=PFNCT(X,NOVAR,A3 ,N,JVAR,NOFNCT,IFER)
     40 IF (IFPRNT)21,22,21
```

```
   22 WRITE OUTPUT TAPE 6,105,RUN,WHT,(I,Z(I),I=1,NOTRMS)
  105 FORMAT(29H0TERMS COMPUTED FROM OBS. NO.F5.0,9H WEIGHT =F10.5/4(8H
     -  TERM(I2,3H) =E15.7)  )
      WRITE OUTPUT TAPE 6,106,Z(NOZ)
  106 FORMAT (9(1H ),4HY  =E15.7,21H (DEPENDENT VARIABLE))
21    CALL RSET8(0)
      RETURN
    7 WRITE OUTPUT TAPE6,120,I,(J,TRMATX(I,J),J=1,60)
  120 FORMAT(15H0ERROR *** TERMI4/4(10H  ELEMENT(I2,3H) =E15.7))
      CALL RSET8(0)
      CALL CORE1
  107 FORMAT(24H0SCALING ERROR *** TERM(I2,3H) =E15.7)
       END                                                          *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    SUMSQ000
C       SUBROUTINE TO LOAD MATRIX AND COMPUTE THE RAW SUMS OF SQUARES
C       AND CROSS PRODUCTS.
        SUBROUTINE SUMSQ
        COMMON NO,NVM1,I,J,RUN,WHT,IFERR,NVP1,ERASE,
       1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
       2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
       3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPREL,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
       4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
       5DEX,X,Z,NOIN,NOEXIT,
       6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
       7MAX,K,NOENT,FLEVEL,CNST,FLEVL
        DIMENSION ERASE(23),
       1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
       2DATA(60),Z(60)          ,
       6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
        EQUIVALENCE (DATA,Z)
         EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
        CALL TAPE1(ITAPE3,NORCD3(2))
        NVP1=NOZ+1
        DO 10 I=1,NVP1
        DO 10 J=1,NVP1
   10 ARRAY5(I,J)=0.
        ASSIGN 32 TO N
        IF (1) 222,222,223
222     GO TO N,(32)
223     CALL FSPILL(N)
32      CONTINUE
        DO 11 N=1,NODATA
        READ TAPE ITAPE3,RUN,(DATA(I),I=1,NOZ  ),WHT
        DO 12 I=1,NOZ
        ARRAY5(I,NVP1)=DATA(I)*WHT+ARRAY5(I,NVP1)
        DO 12 J=1,NOZ
   12 ARRAY5(I,J)=DATA(I)*DATA(J)*WHT+ARRAY5(I,J)
   11 ARRAY5(NVP1,NVP1)=ARRAY5(NVP1,NVP1)+WHT
        DEFR=ARRAY5(NVP1,NVP1)
        IF(DEFR)1,1,2
    2 IFERR=1
        WRITE OUTPUT TAPE 6,100,DEFR
  100 FORMAT(30H WEIGHTED DEGREES OF FREEDOM =F12.2///)
        IF(IFRAW)4,3,4
    3 WRITE OUTPUT TAPE 6,101
  101 FORMAT(53(1H ),14HSUM  OF  TERMS//)
        NVM1=NOTRMS
        WRITE OUTPUT TAPE 6,102,(I,ARRAY5(I,NVP1),I=1,NVM1)
  102 FORMAT(4(10H     TERM(I2,3H) =E15.7))
        WRITE OUTPUT TAPE 6,103,ARRAY5(NOZ  ,NVP1)
  103 FORMAT(10(1H ),5HY   =E15.7)
        WRITE OUTPUT TAPE 6,104
  104 FORMAT(1H0,38(1H ),42HRAW  SUM  OF  SQUARES  AND  CROSS PRODUCTS//
      -)
        CALL PRINT2(ARRAY5,NOZ)
    4 REWIND ITAPE3
        GO TO (5,6),IFERR
    5 RETURN
6       CALL CORE1
    1 WRITE OUTPUT TAPE 6,108,DEFR
  108 FORMAT(17H ERROR *** DEFR =E17.9)
        IFERR=2
        GO TO 3
         END
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          PRCRCN00
C       PARTIAL CORRELATION COEFFICIENTS
        SUBROUTINE PRCRCN
        COMMON NO,NVM1,I,J,IP1,ERASE,
       1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
       2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
       3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
       4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
       5DEX,X,Z,NOIN,NOEXIT,
       6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
       7MAX,K,NOENT,FLEVEL,CNST,FLEVL
        DIMENSION ERASE(26),
       1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
       2DATA(60),Z(60),STDEV(60),
       6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
        EQUIVALENCE (DATA,Z)
        EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
        DEFR=DEFR-1.
        DO 6 I=1,NOZ
        IF (ARRAY5(I,I))1,2,3
    1   IF (ARRAY5(I,I)+TOL)4,5,5
    4   WRITE OUTPUT TAPE 6,100,I,I
  100   FORMAT (18H ERROR *** ARRAY5(I2,1H,I2,15H) TOO NEGATIVE.//)
        CALL PRINT2(ARRAY5,NOZ)
        CALL CORE1
    5   IFSIG=0
        IFCOEN=0
        WRITE OUTPUT TAPE 6,101,I,I,ARRAY5(I,I)
  101   FORMAT (8H ARRAY5(I2,1H,I2,3H) =E17.9)
    2   SIGMA(I)=1.
        GO TO 6
    3   SIGMA(I)=SQRT (ARRAY5(I,I))
    6   ARRAY5(I,I)=1.
        IF(IFSIG)7,8,7
    7   NVM1=NOTRMS
        DO 9I=1,NVM1
        IP1=I+1
        DO 9 J=IP1,NOZ
        ARRAY5(I,J)=ARRAY5(I,J)/(SIGMA(I)*SIGMA(J))
    9   ARRAY5(J,I)=ARRAY5(I,J)
        IF(IFCOEN)10,11,10
   11   WRITE OUTPUT TAPE 6,102
  102   FORMAT (1H0,42(1H ),34HPARTIAL  CORRELATION  COEFFICIENTS//)
        CALL PRINT2(ARRAY5,NOZ)
   10   RETURN
    8   SQDF=SQRT (DEFR)
        DO 12 I=1,NOZ
   12   STDEV(I)=SIGMA(I)/SQDF
        WRITE OUTPUT TAPE 6,103
  103   FORMAT (1H0,49(1H ),20HSTANDARD  DEVIATIONS//)
        CALL PRINT3(STDEV,NOZ)
        GO TO 7
         END
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          RSDSUM00
C       RESIDUAL SUMS OF SQUARES AND CROSS PRODUCTS.
        SUBROUTINE RSDSUM
        COMMON NO,NVM1,I,J,NVP1,IFERR,ERASE,
       1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
       2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
```

```
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
     7MAX,K,NOENT,FLEVEL,CNST,FLEVL
      DIMENSION ERASE(25),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60)          ,
     6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
      EQUIVALENCE (DATA,Z)
      EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
      NVP1=NOZ+1
      IFERR=1
      DO 10 I=1,NOZ
      AVE(I)=ARRAY5(I,NVP1)/ARRAY5(NVP1,NVP1)
      DO 9 J=1,NOZ
    9 ARRAY5(I,J)=ARRAY5(I,J)-AVE(I)*ARRAY5(J,NVP1)
      IF (ARRAY5(I,I))1,2,10
    1 IF (ARRAY5(I,I)+TOL)4,5,5
    4 IFERR=2
    5 WRITE OUTPUT TAPE 6,100,I,I,ARRAY5(I,I)
  100 FORMAT(8H ARRAY5(I2,1H,I2,14H) IS NEGATIVE.E19.9)
      IFAVE=0
      IFRESD=0
      GO TO 10
    2 WRITE OUTPUT TAPE 6,101,I
  101 FORMAT (10H0     TERM(I2,14H) IS CONSTANT.)
   10 CONTINUE
      IF(IFAVE)6,7,6
    7 WRITE OUTPUT TAPE 6,102
  102 FORMAT (1H0,46(1H ),25HAVERAGE  VALUE  OF  TERMS//)
      CALL PRINT3(AVE,NOZ)
    6 IF (IFRESD)11,12,11
   12 WRITE OUTPUT TAPE 6,105
  105 FORMAT (1H0,35(1H ),49HRESIDUAL  SUMS  OF  SQUARES  AND  CROSS  PR
     -ODUCTS//)
      CALL PRINT 2(ARRAY5,NOZ)
   11 GO TO (13,14),IFERR
   13 RETURN
14    CALL CORE1
       END                                                              *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          RGRTRM00
      SUBROUTINE RGRTRM
C     ROUTINE TO TERMINATE REGRESSION PROGRAM
      COMMON NO,NVM1,NSW,ERASE,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
     7MAX,K,NOENT,FLEVEL,CNST,FLEVL
      DIMENSION ERASE(28),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60)          ,
     6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
      EQUIVALENCE (DATA,Z)
      EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
      NSW=1
      NVM1=NOTRMS
      IF(IFSTEP)1,2,1
    1 CALL PRINT1(NSW)
    2 WRITE OUTPUT TAPE 6,100,NOSTEP
  100 FORMAT (29H0REGRESSION TERMINATED AFTER I2,7H STEPS.)
      WRITE OUTPUT TAPE 6,101,(I,ARRAY5(I,I),I=1,NVM1)
  101 FORMAT (1H0,50(1H ),18HDIAGONAL  ELEMENTS//48(1H ),8HVAR. NO.,10(1
     -H ),5HVALUE//(51X     ,I2,E24.9) )
      IF(IFPRED)3,4,3
    4 IF(IFPRDI)5,3,5
    5 CALL PREDCT(0)
    3 RETURN
      END                                                                *
```

```
$COMPILE FORTRAN ,PRINT OBJECT,PUNCH OBJECT                          NRAND000
C
C
C  NRAND -- RANDOM TRIAL CONTROLER   (CALLED FROM WINDUP)
C     (1) TESTS RESULTS OF EACH RANDOM TRIAL DURING THE RANDOM SELECTION
C         PROCESS AND SAVES THE BEST TRIAL.
C     (2) TESTS ICOUNT AGAINST NORAND TO DETERMINE WHETHER SPECIFIED
C         NUMBER OF RANDOM PASSES HAVE BEEN USED.
C  SAVER -- WRITES THE BEST RESULT OF THE RANDOM TRIALS ON TAPE 9 TO BE
C         RESTORED WHEN SPECIFIED NUMBER OF RANDOM TRIALS HAVE BEEN USED.
C
C
      SUBROUTINE NRAND(N)
      COMMON NO,ERASE,ICOUNT,ERAS,ITAPE9,DMY,NORAND,FNAME,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
     7  MAX,K,NOENT,FLEVE,CNST,FLEVL,TERMS,DDMY,SAVRSQ,SAVSIG,SVSGMO,
     8SVCOEN,ISVTRM
       DIMENSION DDMY(1061)
      DIMENSION SVSGMO(60),SVCOEN(60),ISVTRM(60)
      DIMENSION ERASE(8),ERAS(17),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60),
     6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
     7,TERMS(60,60)
      EQUIVALENCE(DATA,Z)
       EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
      NINIT=0
      N=1
      IF(ICOUNT-1)3,67,7
67    WRITE OUTPUT TAPE 6,1001,NOPASS,NORAND
1001  FORMAT(1H0,H1PASS NO. 1,I5,H1 WILL BE EXECUTED 1,I5,H1 TIMES, USIN
     2G RANDOM SELECTION1)
      NOTRSV = 0
  4   CALL SAVER(1)
6     REWIND ITAPE9
      WRITE OUTPUT TAPE 6,103,NOPASS,ICOUNT
 103  FORMAT(13H6 PASS NUMBER,I5,S5,19HRANDOM TRIAL NUMBER,I5)
      READ TAPE ITAPE9,(DEFR,((ARRAY5(IT1,IT2),IT1=1,NOZ),IT2=1,NOZ))
 12   RETURN
 3    ICOUNT=0
      N=6
      GO TO 12
7     WRITE OUTPUT TAPE6,100,SAVSIG,SAVRSQ
100   FORMAT( 38H0BEST PREVIOUS FITTED CURVE PROPERTIES, //23H STANDARD
     -ERROR OF Y = ,E17.7/ 32H COEFFICIENT OF DETERMINATION = ,E15.7)
      TEST = ABSF(RSQ-SAVRSQ)-1.E-04
      IF(TEST) 226,227,227
226   IF(SAVSIG-SIGY) 2,2,1
227   IF(SAVRSQ-RSQ) 1,2,2
2     CONTINUE
      IF(NOTRSV) 79,78,79
78    WRITE OUTPUT TAPE 6,122
```

```
122   FORMAT(55H6CURRENT TRIAL REJECTED IN FAVOR OF THE STANDARD TRIAL.)
      GO TO 80
79    WRITE OUTPUT TAPE 6,102,NOTRSV
102   FORMAT (53H6CURRENT TRIAL REJECTED IN FAVOR OF RANDOM TRIAL NO. I3
     -,1H.)
80    IF (NORAND - ICOUNT) 9,6,6
9     ICOUNT =0
      N=6
      CALL SAVER(-1)
      GO TO 12
1     IF (NOTRSV) 90,91,90
91    WRITE OUTPUT TAPE 6, 2000
2000  FORMAT(55H6STANDARD TRIAL REJECTED IN FAVOR OF THE CURRENT TRIAL.)
      GO TO 105
90    WRITE OUTPUT TAPE 6,101,NOTRSV
101   FORMAT(18H6RANDOM TRIAL NO. I3,39H REJECTED IN FAVOR OF THE CURREN
     -T TRIAL.)
105   NOTRSV = ICOUNT-1
      IF (NCRAND - ICOUNT) 3,4,4
      END                                                              *
```

```
$ ASSEMBLE, PUNCH OBJECT                                    CTERM000
        REM CONSTANT TERM GENERATOR
        ENTRY CTERM
CTERM   SXA     RTRN,4
        CLA*    1,4
        ARS 18
        STO I
        CLA 2,4
        STA     CNXT1
        STA     CNXT2
        CALL    .PRINT
        IOP     FRMT1
        IOP     I
CNXT1   IOP     **
        ENDIO
        CALL    .PUNCH
        IOP     FRMT1
        IOP     I
CNXT2   IOP     **
        ENDIO
RTRN    AXT     **,4
        TRA 3,4
FRMT1   BCD 4S11,2HT(I2,3H) =E17.8*
I       PZE
        END                                                 *
```

```
$ ASSEMBLE, PUNCH OBJECT                                                SUMEQN00
        REM  MAD AND FORTRAN EQUATION SUMMATION AND RETURN GENERATOR
        ENTRY SUMEQN
PRINT1  CALL .PRINT
PUNCH1  CALL .PUNCH
SUMEQN  SXA     RTRN,4
        SXA     GO,4
        SXA     XRB,2
        CLA     3,4
        STA     CHECK
        CLA*    3,4
        TNZ     FORT
        AXT     FRMT1,4
        SXA     FORM1,4
        TRA     GO
FORT    AXT     FRMT11,4
        SXA     FORM1,4
GO      AXT     **,4
        CLA     1,4
        STA     FNAME1
        STA     FNAME2
        STA     FNAME3
        AXT     1,2
        CLA*    2,4
        ARS 18
        STO NIN
        CLA PRINT1
RPT     STA *+1
        TSX **,4
FORM1   STR     **
CHECK   CLA     **
        TZE     *+2
FNAME1  STR     **
        STR NIN
        CLA*    CHECK
        TZE     *+3
FNAME2  STR     **
FNAME3  STR     **
        STR
        TXL     RTRN,2,0
        CLA     PUNCH1
        TXI     RPT,2,-1
RTRN    AXT     **,4
XRB     AXT     **,2
        TRA     4,4
FRMT1   BCD  S11,9HT(0) = 0./S11,31HTHROUGH SUM, FOR I = 1,1,I .G. I2/S7,
        BCD  22HSUM T(0) = T(0) + T(I)/S11,20HFUNCTION RETURN T(0)/S11,15
        BCD 3HEND OF FUNCTION*
FRMT11  BCI *,S11,C6,5H = 0./S11,10HDO 1 I =1,I2/S4,1H1,S6,C6,3H = C6,
        BCI *,7H + T(I)/S11,6HRETURN/S11,3HEND*
NIN     PZE
        END                                                                *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          NRML0000
C
C
C  NRML -- TOTALS THE ARRAYS AND COMPUTES THE NEW WEIGHTS FOR THE
C        VARIABLES, INTERACTION ORDERS, AND FUNCTIONS OF EACH VARIABLE.
C        CALLED FROM CORE3.
C
C
      SUBROUTINE NRML
      COMMON NO,ERASE,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NCRGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     8ARRAY3,ARRAY2,ARRAY1
           DIMENSION ERASE(30),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60)          ,
     4ARRAY1(60),ARRAY2(60,2),ARRAY3(60,60)
      EQUIVALENCE (DATA,Z)
       EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
      N=1
    2 ARRAY1(60) = 0.
      ARRAY2(60,1) = 0.
      DO 1 I = 1,NOIND
6     ARRAY1(60) = ARRAY1(60)+ARRAY1(I)
      ARRAY2(60,1) = ARRAY2(60,1)+ARRAY2(I,1)
      ARRAY3(I,60)=0.
      DO 1 J=1,NOFNCT
    1 ARRAY3(I,60) = ARRAY3(I,60) + ARRAY3(I,J)
      GO TO (3,4),N
4     RETURN
    3 F1 = NOIND
      F2 = NOFNCT
      D1 = F1/ARRAY1(60)
      D2 = F1/ARRAY2(60)
      DO 5 I=1,NOIND
      ARRAY1(I) = ARRAY1(I)*D1
      ARRAY2(I,1) = ARRAY2(I,1)*D2
      D3 = F2/ARRAY3(I,60)
      DO 5 J = 1,NOFNCT
    5 ARRAY3(I,J) = ARRAY3(I,J)*D3
      N=2
      GO TO 2
       END                                                              *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    TAPE1000
C       TAPE HANDLING SUBROUTINE.
        SUBROUTINE TAPE1(I,J)
        REWIND I
        IF(J-1)1,1,2
    2   JM1=J-1
        DO 3 K=1,JM1
    3   READ TAPE I
    1   RETURN
        END                                                          *
```

```
$ASSEMBLE,PUNCH OBJECT, PRINT OBJECT,EXECUTE,FULL DUMP
        REM     MAD AND FORTRAN GENERAL TERM GENERATOR
        REM     WITH SPECIAL FUNCTION PRINTER
        ENTRY GTERM
        ENTRY   GENTRM
PRINT1  CALL    .PRINT
PUNCH1  CALL    .PUNCH
XRB     TXH 2,0,0
GTERM   STZ     F
        CLA     =1
        STO     M                       M=1,MAD
        TRA     *+4
GENTRM  CLA     =1
        STO     F                               F=1,FORTRAN
        STZ     M
        CLA*    4,4
        ARS     18
        STO     U                               U=1, SPECIAL FUNCTION
        CLA     =1
        SUB     U
        STO     X                               X=1, EXPONENT
        SXA     RTRN,4
        SXA     IX2,2
        SXA     IX1,1
        LXA XRB,2
        SXD XRB,2
        CLA*    1,4
        ARS 18
        STO I
        CLA*    2,4
        ARS 18
        STO J
        CLA NRM
        STO WRD
        CLA NRM+1
        STO WRD+1
        CLA 3,4
        STA EXPNT1
        STA     EXPNT2
        STA EXPT1
        ZET     U
        TRA FLOAT1+2
        CLA*    3,4
        FSB CNE
        TNZ EXPT2
        CAL TXL
        TRA STO
EXPT2   FAD CNE
        UFA A
        LRS 27
        PXD 0,0
        LLS 27
FIX3    STO FIX
        ORA A
        FAD A
EXPT1   FSB **
        TNZ FLOAT1
        CLA FIX3
        STA EXPNT1
```

```
        CLA FIX2
        TRA END1
FLOAT1  NZT     U
        TRA     *+3
        CLA     ENDING+1
        TRA     END1
        ZET     F
        TRA     SKIPAB
        CLA     ABS
        STO WRD
        CLA ABS+1
        STO WRD+1
SKIPAB  CLA     FLOAT2
END1    STO ENDING
        CAL XRB
STO     STP SW1
        CLA PRINT1
RPT     STA *+1
        TSX **,4
        STR     SYMTAB,*FRMT1
        STR I
        STR I
        NZT     U
        TRA     *+3
EXPNT2  STR     **
        STR     PAREX
        STR J
        ZET     U
        TRA     FINI
SW1     TXL     FINI
        ZET     F
        STR WORD2
        NZT     F
        STR     WORD1
        NZT     U
EXPNT1  STR     **
FINI    STR
        LXD XRB,2
        TNX RTRN,2,1
        SXD XRB,2
        CLA PUNCH1
TXL     TXL RPT
RTRN    AXT     **,4
IX1     AXT     **,1
IX2     AXT     **,2
        TRA     5,4
ONE     DEC 1.
A       OCT +233000000000
FRMT1   BCD 5S11,2HT(I2,6H) = T(I2,4H) *
WRD     BCD 2
        BCI     *, *X*(1HX,I2,C6),*U*(C6,*M*(1H.),C2,I2)
ENDING  BCD 1
        BCD 1,1H)*
FIX2    BCD 1,I3
FLOAT2  BCD 1,F10.6
WORD1   BCI    *, .P. (
WORD2   BCI    *, **  (
PAREX   BCI     1,(X
ABS     BCD 2     6H.ABS.
```

```
NRM     BCD 2           1H
        ZERO    F,U,X,I,J,FIX,M
        BCI     1,F
        PZE     F,1
        BCI     1,U
        PZE     U,1
        BCI     1,X
        PZE     X,1
        BCI     1,M
        PZE     M,1
SYMTAB  PZE     8
        END                                                              *
$ ASSEMBLE, PUNCH OBJECT                                        RGRSSN00
        REM REGRESSION  SUBROUTINE MAINBODY
        ENTRY RGRSSN
RGRSSN  SXD XRC,4
        CLA 1,4
        STA SW1
8A      CALL DGFRDM
SW1     LXD **,4
10A     TRA 10A+5,4
        TRA 17A
        TRA 14A
        TRA 11A
        TRA 20A
11A     CALL VARSRT
        TRA SW1
14A     CALL VARCHK
        TRA SW1
17A     CALL MATRAN
        TRA 8A
20A     LXD     XRC,4
        CLA*    2,4
        TNZ     1,4
        CALL    RGRTRM
        LXD XRC,4
LAST    TRA 1,4
XRC     PZE
        REM
MATRAN  REM         TRANSFORMS THE REGRESSION MATRIX.
RGRTMN  REM         (1) PRINTS OUT THE LAST REGRESSION STEP.
        REM         (2) CONTROLS PRINTING OF PREDICTIONS OF EQUATION.
        REM
        END                                                              *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                          PREDCT00
C      PREDICTION ROUTINE.
       SUBROUTINE PREDCT
       COMMON NO,ERASE,
      1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
      2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
      3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
      4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
      5DEX,X,Z,NOIN,NOEXIT,
      6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
      7MAX,K,NOENT,FLEVEL,CNST,FLEVL
       DIMENSION ERASE(30),
      1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
      2DATA(60),Z(60)          ,
      6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
       EQUIVALENCE (DATA,Z)
        EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
       IF(NOIN)20,20,1
    1  CALL TAPE1(ITAPE3,NORCD3(2))
       WRITE OUTPUT TAPE 6,100
  100  FORMAT (1H0,39(1H ),40HPREDICTED  RESULTS  VERSUS  DATA  POINTS//9
      -H OBS. NO.,21(1H ),11HPREDICTIONS,34(1H ),4HDATA,19(1H ),10HDEVIAT
      -IONS/12(1H ),9HY - SIGMA,14(1H ),1HY,16(1H ),9HY + SIGMA,13(1H ),6
      -HPOINTS,12(1H ),10H(DATA - Y),5(1H ),7HPERCENT)
       BIGPCT=0.
       NMXPCT=0
       BIGDEV = 0.
       NMAX = 0
       DO 10 N1=1,NODATA
       READ TAPE ITAPE3,RUN,(DATA(I),I=1,NOZ),WHT
       Y=CNST
       I1=0
       DO 11 I2=1,NOTRMS
       IF(INDEX(I2))25,11,25
25     I1=I1+1
       Y=Y+COEN(I1)*DATA(I2)
11     CONTINUE
       YPSIG=Y+SIGY
       YMSIG=Y-SIGY
       DEV=DATA(NOZ)-Y
       PCT=(DEV/DATA(NOZ))*100.
       ABDEV = ABSF(DEV)
       ABPCT=ABSF(PCT)
       IF(ABDEV-BIGDEV)4,4,2
    2  BIGDEV = ABDEV
       NMAX = N1
       RUNMX=RUN
    4  IF(ABPCT-BIGPCT)10,10,3
    3  BIGPCT=ABPCT
       NMXPCT=N1
       RUNMXP=RUN
   10  WRITE OUTPUT TAPE 6,101,RUN,YMSIG,Y,YPSIG,DATA(NOZ),DEV,PCT
  101  FORMAT(F7.0,E17.8,E19.8,E21.8,E19.8,E21.8,F10.3)
  102  FORMAT(29H0MAXIMUM ABSOLUTE DEVIATION =E15.7,14H,(SEE OBS. NO.F4.0
      -,10H, LINE NO.I3,1H))
  103  FORMAT(37H0MAXIMUM ABSOLUTE PERCENT DEVIATION =F10.3,14H,(SEE OBS.
      - NO.F4.0,10H, LINE NO.I3,1H))
       REWIND ITAPE3
       WRITE OUTPUT TAPE 6,102,BIGDEV,RUNMX,NMAX
```

```
      WRITE OUTPUT TAPE 6,103,BIGPCT,RUNMXP,NMXPCT
   20 RETURN
      END                                                              *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    PRINT100
C       SPECIAL PRINTER ROUTINE NO.1
        SUBROUTINE PRINT1(NSW)
        COMMON NO,ERASE,
       1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
       2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
       3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
       4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
       5DEX,X,Z,NOIN,NOEXIT,
       6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
       7MAX,K,NOENT,FLEVEL,CNST,FLEVL
        DIMENSION ERASE(30),
       1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
       2DATA(60),Z(60)          ,
       6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
        EQUIVALENCE (DATA,Z)
        EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
     1  IF(NOENT)3,3,2
     3  WRITE OUTPUT TAPE 6,100,NOSTEP,K
   100  FORMAT (9H0STEP NO.I5/ 15H   TERM REMOVEDI4)
        GO TO 4
     2  WRITE OUTPUT TAPE 6,101,NOSTEP,K
   101  FORMAT (9H0STEP NO.I5/ 15H   TERM ENTEREDI4)
     4  WRITE OUTPUT TAPE 6,102,FLEVEL,SIGY,RSQ,R,CNST
   102  FORMAT (12H   F LEVEL =E32.9/24H   STANDARD ERROR OF Y = E20.9/27H
       -   COEFF OF DETERMINATION =E17.9/26H   MULTIPLE CORLTN COEFF =E18.
       -9//18H   CONSTANT TERM = E26.9/S7,8HTERM NO.8X11HCOEFFICIENT8X17HS
       -TD ERR OF COEFF 8X8HF LEVEL )
        J = 0
        DO 11 I = 1, NOTRMS
        IF (INDEX(I)) 22,11,22
22      J = J + 1
        WRITE OUTPUT TAPE 6,104,I,COEN(J),SIGMCO(J),FLEVL(J)
11      CONTINUE
104     FORMAT(4X5HTERM-I3,E24.9,E22.9,E19.9)
     7  RETURN
        END
```

```
$COMPILE MAD,PRINT OBJECT,PUNCH OBJECT,EXECUTE I/ODUMP                DATARD000
          EXTERNAL FUNCTION (NP,VEC)
          E'O DATARD.
          N'S INTEGER
          D'N V(71)
          NOSPFN = NP .RS. 18 -1

READ      R'T $72C1*$,V...V(71)
          J = 0
          T'H LL, FOR I = 0, 1, I.G.71
          W'R V(I) .NE. $$
          V(J) = V(I)
          J = J + 1
LL        E'L

          (I=J,1, I .G. 71, V(I) = $$)

          J1 = 0
          T'H M, FOR K = 0,1, K .G. NOSPFN
          T'H N, FOR L = J1, 1, V(L) .E. $.$
          W'R V(L) .E. $$
          W'RL.NE. J1, T'O ERR
          W'R K .E. NOSPFN, F'N 1.
          T'O READ
N         E'L
          GATHER.(VEC(K),$6C1*$,V(J1)...V(L-1))
          W'R V(L+1) .E. $,$, L = L + 1
M         J1 = L + 1
          F'N 0
ERR       PRINT COMMENT $6***ERROR ... ILLEGAL FORMATION IN SPECIAL FUN
         1CTION SPECIFICATION.$
          F'N 0
          E'N                                                          *
```

```
$COMPILE FORTRAN,PRINT OBJECT,PUNCH OBJECT                    CMTRWT 000
C      TERM WEIGHT COMPUTER
       SUBROUTINE CMTRWT
        COMMON NO, ERASE,
      1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
      2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
      3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
      4DIT,NCRGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
      5DEX,X,Z,NOIN,NOEXIT,
      8ARRAY3,ARRAY2,ARRAY1
        DIMENSION ERASE(30),
      1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
      2DATA(60),Z(60)          ,
      4ARRAY1(60),ARRAY2(60,2),ARRAY3(60,60)
        EQUIVALENCE (DATA,Z)
            EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
        CALL TAPE1(ITAPE3,NORCD3(1))
        DO 1 I=1,NOIND
6       ARRAY1(I)=1.
        ARRAY2(I,1)=1.
        DO 2 J=1,NOFNCT
      2 ARRAY3(I,J)=1.
      1 ARRAY3(I,60)=NOFNCT
        ARRAY1(60)=NOIND
        ARRAY2(60,1)=NOIND
        WRITE TAPE ITAPE3,ARRAY1,ARRAY2,ARRAY3
        RETURN
         END                                                    *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    DGFRDM00
C      DEGREE OF FREEDOM SUBROUTINE.
       SUBROUTINE DGFRDM
       COMMON NO,ERASE,
      1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
      2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
      3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
      4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
      5DEX,X,Z,NOIN,NOEXIT,
      6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
      7MAX,K,NOENT,FLEVEL,CNST,FLEVL
       DIMENSION ERASE(30),
      1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
      2DATA(60),Z(60)          ,
      6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
       EQUIVALENCE (DATA,Z)
       EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
       IF(ARRAY5(NOZ,NOZ))10,1,2
    1  WRITE OUTPUT TAPE 6,100,ARRAY5(NOZ,NOZ)
  100  FORMAT (24H ERROR *** ARRAY5(Y,Y) =E15.7)
    4  N=1
    5  RETURN
   10  IF(ABSF(ARRAY5(NOZ,NOZ)) - TOL)12,12,1
   12  WRITE OUTPUT TAPE 6,102,ARRAY5(NOZ,NOZ)
  102  FORMAT(15H ARRAY5(Y,Y) = E15.7)
       ARRAY5(NOZ,NOZ)= ABSF(ARRAY5(NOZ,NOZ))
    2  NOSTEP=NOSTEP+1
       SIGY = SIGMA(NOZ)*SQRT (ARRAY5(NOZ,NOZ)/DEFR)
       RSQ=1.-ARRAY5(NOZ,NOZ)
       RSQ = ABSF(RSQ)
        R=SQRT(RSQ)
       DEFR=DEFR-1.
       IF(DEFR)3,3,6
    6  N=2
       GO TO 5
    3  WRITE OUTPUT TAPE 6,101
  101  FORMAT (28H NO MORE DEGREES OF FREEDOM.)
       GO TO 4
        END                                                      *
```

```
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                    WINDUP00
C  WINDUP --
C     (1) CALLS ON THE ROUTINES WHICH CONTROL THE RANDOM SELECTION
C         MECHINISMS.
C     (2) TESTS THE RESULTS OF EACH REGRESSION ANALYSIS TO DETERMINE
C         WHETHER OR NOT THE GIVEN CRITERION HAVE BEEN MET.
C     (3) TESTS THE RESULTS OF EACH PASS AND SAVES THE BEST PASS.
C     (4) CALLED FROM CORE 6.
C  NRAND -- RANDOM TRIALS CONTROLER.
C     (1) TESTS THE RESULTS OF EACH REGRESSION TRIAL DURING THE RANDOM
C         SELECTION PROCESS AND SAVES THE BEST TRIAL.
C     (2) TESTS TO DETERMINE WHEN THE SPECIFIED NUMBER OF RANDOM TRIALS
C         HAVE BEEN USED.
C  CORE3 -- THE EDITOR PROGRAM.
C     (1) CONTROLS THE GRADING OF INTERACTION ORDERS, EXPONENTS, AND
C         VARIABLES.
C     (2) SELECTS NEEDED TERMS TO REFILL THE SPECIFIED NUMBER OF
C         TERMS.
C
C
      SUBROUTINE WINDUP
      COMMON NO,ERASE,ICOUNT,ERAS,NOPASK,NOINKP,ER,NBEGIN,DMY,NORAND,
     1 FNAME,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPREL,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
     7MAX,K,NOENT,FLEVEL,CNST,FLEVL
      DIMENSION SEEPCN(60)
      DIMENSION ERASE(8),ERAS(5),ER(2),DMY(9),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60)          ,
     6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
      EQUIVALENCE (DATA,Z)
          EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
      IF(ICOUNT) 202,202,246
246   IF(NO) 247,202,247
247   WRITE OUTPUT TAPE 6, 10000
10000 FORMAT(59H0RANDOM TRIALS DELETED BECAUSE NO TERMS WERE SIGNIFICANT
     -.    )
      ICOUNT = NORAND +1
      GO TO 206
202   WRITE OUTPUT TAPE 6,106
      WRITE OUTPUT TAPE 6,107,SIGMAY,CODTRM
      WRITE OUTPUT TAPE 6,108
      WRITE OUTPUT TAPE 6,107,SIGY,RSQ
  106 FORMAT(20H0POSTULATED CRITERIA)
  107 FORMAT(22H0STANDARD ERROR OF Y =E17.7/25H COEFF OF DETERMINATION =
     -E15.7)
  108 FORMAT(24H0FITTED CURVE PROPERTIES)
      IS=0
200   N=0
      IF(SIGMAY - SIGY)1,2,2
    2 N = N + 1
    1 IF(CODTRM - RSQ)4,4,3
```

```
     3 N = N + 2
       GO TO 55
     4 N = N + 4
55     IF(IS)36,56,5
56     IF(ICOUNT)5,5,205
205    IF(N-5)206,9,206
206    IS=1
       CALL NRAND(N)
C         WHEN RETURNING FROM NRAND, N = 6 IF ALLOWED NUMBER OF RANDOM
C         TRIALS HAVE BEEN USED, N = 1 OTHERWISE.
 5     GO TO (16,6,7,8,9,202),N
    6  WRITE OUTPUT TAPE 6,100
  100  FORMAT(37H0FITTED CURVE MEETS NEITHER CRITERIA.)
       GO TO 10
    7  WRITE OUTPUT TAPE 6,101
  101  FORMAT(46H0FITTED CURVE MEETS ONLY STD. ERROR CRITERION.)
       GO TO 10
    8  WRITE OUTPUT TAPE 6,102
  102  FORMAT(58H0FITTED CURVE MEETS ONLY COEF. OF DETERMINATION CRITERIO
      -N.)
10     CONTINUE
       IF (NBEGIN) 45,444,45
444    NBEGIN = 1
       GO TO 46
45     TEST = ABSF(RSQ-SPRSQ)-1.E-04
       IF(TEST) 226,227,227
226    IF(SPSIGY-SIGY)47,227,44
227    IF(SPRSQ-RSQ) 44,47,47
44     WRITE OUTPUT TAPE 6,1004
1004   FORMAT(33H6CURRENT PASS IS THE BEST SO FAR.)
46     SPRSQ = RSQ
       SPSIGY=SIGY
       NOINKP = NOIN
       NOPASK = NOPASS
       DO 48 I = 1,NOIN
48     SEEPCN(I)=COEN(I)
       GO TO 11
47     CONTINUE
       NOIN = NOINKP
       DO 49 I = 1,NOIN
       INDEX(I) = I
49     COEN(I) = SEEPCN(I)
       I=NOIN+1
       DO 50 I=I,60
50     INDEX(I)=0
       WRITE OUTPUT TAPE 6,111,NOPASK
111    FORMAT(39H0CURRENT PASS REJECTED IN FAVOR OF PASS,I5,1H.)
11     IF(NOPASS - NOTRYS)20,12,12
20     NOPASS = NOPASS+1
       WRITE OUTPUT TAPE 6,103,NOPASS,NOPROB,NOTRYS
  103  FORMAT(13H0PASS NUMBER I4,22H BEGUN FOR PROBLEM NO.I5/1H I4,22H TO
      -TAL PASSES ALLOWED.)
   13  NOEXIT = 2
14     CALL CORE3
   12  WRITE OUTPUT TAPE 6,104,NOPROB,NOPASS
  104  FORMAT(12H0PROBLEM NO.I5,17H TERMINATED AFTERI5, 8H PASSES./1H6)
   15  NOEXIT = 1
       GO TO 14
   16  RETURN
```

```
    9 WRITE OUTPUT TAPE 6,105
      ICOUNT=0
  105 FORMAT(34H0FITTED CURVE MEETS BOTH CRITERIA.)
      GO TO 12
       END                                                              *
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                        PARAM000
C
C
C  PARAM --
C     (1) READS IN THE LAST THREE CONTROL CARDS.
C     (2) ESTABLISHES VALUES FOR PARAMETERS IN COMMON.
C     (3) CALLED FROM CORE1.
C  STDRD -- ESTABLISHES STANDARD VALUES FOR THOSE PARAMETERS WHICH WERE
C        NOT SET BY THE USER.
C  ALTRMS -- COMPUTES THE TOTAL NUMBER OF POSSIBLE TERMS.
C
C
      FUNCTION PARAM
       COMMON NO,NDMY,I,DMY,NUMCDS,ERASE,IFLRN,IFOUT,NOINTR,
     6IFPCH,ERA,NBGIN,ERSA,ITAPE9,IFRWDA,NORAND,FNAME,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,ERAAS,NOSPFN
       DIMENSION ERA(5),ERSA(7),ERAAS(8576),DMY(5),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60)
       EQUIVALENCE (DATA,Z)
       EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
C           READ SECOND CONTROL CARD
       READ INPUT TAPE 7,100,CODTRM,SIGMAY,PRBIN,PRBOUT,TOL,NOIND,NOTRYS,
     1NOFNCT,NOTRMS,IFMORE
  100  FORMAT(5F10.5,4I5,I2)
C           READ THIRD CONTROL CARD
       READ INPUT TAPE 7,101,IFRWDA,IFRAW,IFAVE,IFRESD,IFSIG,
     3IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,IFOUT,NORAND,IFPCH,IFLRN,NOINTR
     1,NOINIT,NOINT,IFCNST,IFWT,NUMCDS
     2,NOPROB,FNAME,IFTRWT,NOSPFN
  101  FORMAT(14I1,I4,3I5,I1,I4,I5,A6,2I2)
C          READ FOURTH CONTROL CARD
       READ INPUT TAPE7,103,NORGRS,(GRADES(I), I=1,NORGRS)
  103  FORMAT(I5,4E16.8/(E21.8,3E16.8))
       NBGIN=0
       IF (NOIND) 988,988,987
  988  WRITE OUTPUT TAPE 6,1000
 1000  FORMAT (64H0*****  NO INDEPENDENT VARIABLES SPECIFIED.  ERROR TERM
     -INATION.        )
       CALL ERROR
  987  PARAM = 0.
       IF (NORGRS) 321,321,322
  321  NORGRS = 3
       GRADES(1)=3.0
       GRADES(2)=3.0
       GRADES(3)=1.5
  322  CALL STDRD(NOFNCT,NOTRYS,NOINTR,IFCNST,NUMCDS,NOTRMS,TOL,PRBIN,PRB
     1OUT,CODTRM,NOPROB,FNAME)
```

```
      NUMCDS=NUMCDS*12
      NORGRS = -NORGRS
      IF (IFMORE) 777,777,778
778    DO 779 III=1,IFMORE
      READ INPUT TAPE 7, 1111
1111  FORMAT(72H
     -                          )
      WRITE OUTPUT TAPE6,1111
779    CONTINUE
777   CONTINUE
307   ALTG=NOTRMS
         ALTP=ALTRMS(NOINTR,NOIND,NOFNCT)
      IF(IFCNST)4260,4261,4261
4260  ALTP=ALTP+1.
4261     WRITE OUTPUT TAPE 6,107,ALTP
107      FORMAT (16HOPOSSIBLE TERMS=,F10.0)
         IF (ALTP-ALTG) 4,5,5
4        WRITE OUTPUT TAPE 6,108
108      FORMAT (14HOTERMS REDUCED)
      NOTRMS=ALTP
5        CONTINUE
       ITAPE3=3
       NORCD3(1)=1
       NORCD3(2)=2
       NORCD3(3)=2
       ITAPE4=4
       NORCD4(1)=1
      NOVAR=NOIND+1
      NOZ=NOTRMS+1
      LRAM(1)=0.
      IF(NOINIT)1,1,2
    1 NOINIT=0
      GO TO 3
C          IF ORDER OF TERMS INSERTED IS SPECIFIED
    2 READ INPUT TAPE 7,106,(INVAR(I),I=1,NOINIT)
  106 FORMAT(1415)
3     RETURN
       END                                                          *
```

```
$ COMPILE FORTRAN,PRINT OBJECT,PUNCH OBJECT                    STUDN000 CORE3
C
C
C  CORE3 -- THE STUDENT.
C    (1) CONTROLS THE LEARNING PROCEDURES.
C    (2) CALLED FROM CORE1, CORE4, AND FROM WINDUP.
C  TAPE1 -- TAPE1(I,J) SPACES TAPE I BY J RECORDS.
C  GRADER -- GRADES THE INTERACTION ORDERS, POWERS, AND VARIABLES ON
C        THEIR PREFORMANCE IN THE REGRESSION ANALYSIS.
C  NRML -- SUMS THE VARIOUS SELECTOR ARRAYS AND REASSIGNS THE NEW
C        WEIGHTED VALUES TO EACH.
C  PRINT4 -- PRINTS OUT THE SELECTION ARRAYS AFTER LEARNING.
C
C  PKTRM -- PICKS NEW TERMS TO REFILL THE TERMS ARRAY.
C
C  TRMCHK -- CHECKS FOR THE INDEPENDENCE OF THE TERMS.
C  CORE4 -- THE EDITOR PROGRAM.
C    (1) CHECKS EACH TERM FOR COMPATIBILITY WITH THE MACHINE WORD SIZE.
C    (2) EVALUATES EACH TERM FOR ALL DATA SETS.
C
C
          SUBROUTINE CORE3
      COMMON NO,ERASE,IFLRN,ERASS,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     8ARRAY3,ARRAY2,ARRAY1,DMYXXX,TERMS,DMY,NOSPFN
      DIMENSION ERASE(9),ERASS(20),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60),TERMS(60,60),DMYXXX(136),
     4 ARRAY1(60),ARRAY2(60,2),ARRAY3(60,60),DMY(1060)
      EQUIVALENCE (DATA,Z)
         EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
      IF (NOPASS) 76,40,40
   40 CALL TAPE1(ITAPE3,NORCD3(1))
      READ TAPE ITAPE3,ARRAY1,ARRAY2,ARRAY3
      CALL TAPE1(ITAPE3,NORCD3(3))
      IF(IFCNST)1,2,2
1     IF(INDEX(1)) 800,800,111
11 1  I1=2
      NOCNT=1
      GO TO 3
800   IFCNST = 1
      I1=2
      GO TO 801
    2 I1=1
801   NOCNT=0
    3 NIN = XABSF(NOIN)
      FIN = NOFNCT - NOSPFN
      DO 4 I=I1,NOTRMS
      NO=I
      N=2
      IF(NOIN)30,5,6
C        NOIN IS NEGATIVE IF RETURNING FROM CORE4,POSITIVE IF COMING
C        FROM WINDUP, AND ZERO IF COMMING FROM CORE1.
```

```
    30 N=3
6      IF (INDEX(I))  8,5,8
     8 NOCNT=NOCNT+1
       IF(NOCNT-I)17,9,9
17     DO 171 J=1,NOIND
171    TERMS(NOCNT,J)=TERMS(I,J)
       TERMS(NOCNT,60)=TERMS(I,60)
       GO TO 9
     5 N=1
C      AT THIS POINT, N=1 IF TERM UNSUCCESSFUL, N=2 IF TERM SUCCESSFUL
C      N=3 IF TERM RETAINED WITHOUT GRADING
9      GO TO (31,31,4),N
    31 CALL GRADER(ARRAY1,ARRAY2,ARRAY3,TERMS,NOTRMS,NOIND,FIN    ,N,GRADE
      -S,NOPROB,NORGRS)
     4 CONTINUE
       CALL NRML
       IF(IFLRN) 32,32,11
32     CALL PRINT4
11     IF (NOCNT)13,13,14
14     IF (NOCNT+1-NOTRMS)13,13,16
76     NOCNT = 0
       CALL CMTRWT
       NOPASS = -NOPASS
    13 J1=NOCNT+1
20     DO 18 I=J1,NOTRMS
       NO = I
    19 CALL PKTRM(TERMS,LRAM,ARRAY1,ARRAY2,ARRAY3,NOIND,NOFNCT)
       CALL TRMCHK(N1,NOCNT,TERMS,NOIND,NOSTRT)
       GO TO (19,18),N1
    18 CONTINUE
       NOEXIT=NOEXIT
       GO TO (21,22),NOEXIT
    22 CALL TAPE1(ITAPE3,NORCD3(1))
       WRITE TAPE ITAPE3,ARRAY1,ARRAY2,ARRAY3
       CALL CORE4
    16 WRITE OUTPUT TAPE 6,100
   100 FORMAT (58H0TERM MATRIX FILLED WITH OLD TERMS.  FRESH SELECTION MA
      -DE.)
       NOCNT = I1-1
       GO TO 13
21     IF (IFPCH) 12,12,10
10     IF(IFLRN)12,12,900
900    CALL PRINT4
12     CALL CORE7
            RETURN
   101 FORMAT(5E14.7)
   102 FORMAT(14F5.0)
       END                                                              *
$ COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT                  VARCHK00
C      VARCHK COMBINED WITH VINCHK. ALLOWS S.O. OR
C      TERM INSERTION,AS DESIRED.
       SUBROUTINE VARCHK
       COMMON NO,NSW,I,ERASE,ICOUNT,ERA,
      1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
      2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
      3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
      4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
      5DEX,X,Z,NOIN,NOEXIT,
      6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
```

```
     7MAX,K,NOENT,FLEVEL,CNST,FLEVL
      DIMENSION ERASE(6),ERA(21),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60)          ,
     6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
      EQUIVALENCE (DATA,Z)
      EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
   30 IF(NOSTEP-NOINIT-1)1,2,2
    1 NSW=2
    3 IF(NOSTEP-1)20, 4,4
    4 IF (IFCNST)6,7,6
    6 CNST=0.
    8 IF (IFSTEP)9,10,9
    9 GO TO (11,12),NSW
    2 NSW=1
      GO TO 3
   20 WRITE OUTPUT TAPE6,100,SIGY
  100 FORMAT (1H021HSTANDARD ERROR OF Y =E17.9)
      IF (IFCNST) 462,12,12
462   N=4
      INDEX(1)=1
      K=1
      NOENT=1
      GO TO 17
    7 CNST=AVE(NOZ)
      J = 0
      DO 41 I = 1, NOTRMS
      IF (INDEX(I)) 14,41,14
14    J = J + 1
      CNST = CNST - AVE(I) * COEN(J)
41    CONTINUE
      GO TO 8
   10 CALL PRINT1(NSW)
      IF (IFPRDI)9,15,9
   15 CALL PREDCT(0)
      GO TO 9
   11 N=1
      IF(NOIN)26,26,16
26    N=2
      GO TO 16
163   K=NOMAX
      NOENT=K
      N=4
      INDEX(NOMAX)=1
      GO TO 188
16    IF(ICOUNT)1169,1169,350
350   IF (NO) 1168,163,1168
1168  IF (NOSTEP) 1169,1169,2268
2268  NO = 0
1169  CALL TSTLVL
188   GOTO (17,18),NSW
   18 NINIT = XMAXOF(0,NINIT-1)
   17 RETURN
   12 N=3
      GO TO 16
       END                                                              *
```

```
$ COMPILE FORTRAN,PUNCH OBJECT,PRINT OBJECT                    FCT00000
      FUNCTION FCT(NUM)
      FN=NUM
      IF (FN-30.) 6,6,7
7     FCT=1.E30
      RETURN
6     CONTINUE
      FCT=1.
1     IF (FN-1.) 3,3,2
2     FCT=FCT*FN
      FN=FN-1.
      GO TO 1
3     RETURN
      END                                                      *
```

```
$ COMPILE FORTRAN,PRINT OBJECT,PUNCH OBJECT                    FLVL0000
      FUNCTION FLVL(P,D)
      IF(P)2,2,1
    1 IF(P-1.)8,9,9
    8 IF(D)2,2,3
    3 FLVL=-3.48265507+((-.151687965E03*D**(-5))+(.680817276E01*D**(-1)
     X))*P**(-.5)+(.518849328E01-.378849201E01*D**(-.33333333)-.27726566
     XE01*D**(-1)+.100921422E03*D**(-5))*P**(-.2)+(.753659189E01*D**(-4)
     X-.335350573E-02+.378218263E02*D**(-6))*P**(-1)-.1288222518E00*D**(
     X.33333333)-.605177797E-13*P**(-5)*D**(-1)
      IF(FLVL)9,5,5
    2 FLVL=1.E10
      GO TO 5
    9 FLVL=0.
    5 RETURN
      END
```

```
$COMPILE FORTRAN,PRINT OBJECT,PUNCH OBJECT                          SAVER000
      SUBROUTINE SAVER(ISWTCH)
C     SUBROUTINE TO SAVE REGRSSN MATRIX AND STATISTICS
      COMMON NO,ERASE,ITAPE9,DMY,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NCEXIT,
     6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
     7  MAX,K,NOENT,FLEVE,CNST,FLEVL,TERMS,DDMY,SAVRSQ,SAVSIG,SVSGMO,
     8SVCOEN,ISVTRM
       DIMENSION DDMY(1061)
      DIMENSION FLEVL(60)
      DIMENSION SVSGMO(60),SVCOEN(60),ISVTRM(60)
      DIMENSION ERASE(26),COEN(60),DMY(3),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2DATA(60),Z(60),TERMS(60,60),ARRAY5(61,61),SIGMA(60),SIGMCO(60)
       EQUIVALENCE (DATA,Z)
          EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
      IF(ISWTCH)1,1,2
1     NOIN = NOINSV
      DO 3 ITER=1,NOIN
      SIGMCO(ITER)=SVSGMO(ITER)
      COEN(ITER)=SVCOEN(ITER)
3     CONTINUE
      DO 4 ITER=1,NOTRMS
4     INDEX(ITER)=ISVTRM(ITER)
      RSQ=SAVRSQ
      SIGY=SAVSIG
      CNST = SVCNST
      READ  TAPE ITAPE9,(DEFR,((ARRAY5(IT1,IT2),IT1=1,NOZ),IT2=1,NOZ))
      REWIND ITAPE9
12    RETURN
2     WRITE TAPE ITAPE9,(DEFR,((ARRAY5(IT1,IT2),IT1=1,NOZ),IT2=1,NOZ))
      REWIND ITAPE9
      DO 5 ITER=1,NOIN
      SVSGMO(ITER)=SIGMCO(ITER)
      SVCOEN(ITER)=COEN(ITER)
5     CONTINUE
      DO 6 ITER=1,NOTRMS
6     ISVTRM(ITER)=INDEX(ITER)
      SAVRSQ=RSQ
      SAVSIG=SIGY
      NOINSV = NOIN
      SVCNST = CNST
      GO TO 12
      END                                                               *
```

```
$COMPILE FORTRAN, PRINT OBJECT, PUNCH OBJECT, EXECUTE, DUMP      CORE6000
C
C
C  CORE6 --
C     (1) SETS UP THE TAPES FOR RANDOM TRIALS.
C     (2) STARTS THE REGRESSION ANALYSIS.
C     (3) CALLED FROM CORE 4.
C  SUMSQ -- COMPUTES THE RAW SUM OF SQUARES AND THE CROSS PRODUCTS.
C
C  RSDSUM -- CALCULATES THE RESIDUAL SUMS OF SQUARES AND CROSS PRODUCTS.
C
C  PRCRCN -- CALCULATES THE PARTIAL CORRELATION COEFFICIENTS OF THE DATA
C
C  RGRSSN -- THE SUBROUTINE WHICH CONTROLS THE REGRESSION ANALYSIS.
C
C  PRINT1 -- PRINTS OUT THE FINAL STEP OF THE REGRESSION FOR EACH
C         RANDOM TRIAL.
C  WINDUP --
C     (1) CALLS ON THE ROUTINES WHICH CONTROL THE RANDOM SELECTION
C         MECHINISMS.
C     (2) TEST RESULTS OF EACH REGRESSION ANALYSIS TO DETERMINE WHETHER
C         OR NOT THE GIVEN CRITERION HAVE BEEN MET.
C     (3) TESTS THE RESULTS OF EACH PASS AND SAVES THE BEST PASS.
C
C
      SUBROUTINE CORE6
      COMMON NO,J1,ERASE,ICOUNT,
     1DMMY,IFOUT,ERAS,NOPASK,NOINKP,EERAS,ITAPE9,DM,NORAND,FNAME,
     1NOPROB,TOL,PRBIN,PRBOUT,NOIND,NOVAR,NOFNCT,NOTRMS,NOZ,NODATA,NOINT
     2,NOINIT,IFCNST,IFWT,CODTRM,SIGMAY,NOTRYS,IFTRWT,IFRAW,IFAVE,IFRESD
     3,IFSIG,IFCOEN,IFSTEP,IFPRDI,IFPRED,IFPRNT,GRADES,NOSTRT,NSTDNT,NOE
     4DIT,NORGRS,ITAPE3,NORCD3,ITAPE4,NORCD4,LRAM,INVAR,NOSTEP,NOPASS,IN
     5DEX,X,Z,NOIN,NOEXIT,
     6ARRAY5,DEFR,SIGMA,SIGMCO,NINIT,N,SIGY,RSQ,R,VMAX,VMIN,VAR,NOMIN,NO
     7  MAX,K,NOENT,FLEVEL,CNST,FLEVL,TERMS,DMY,FUNC,NOSPFN
      DIMENSION ERASE(7),ERAS( 5),EERAS(8),TERMS(60,60),
     1GRADES(12),NORCD3(5),NORCD4(5),LRAM(3),INVAR(60),X(120),INDEX(60),
     2  DATA(60),Z(60),FUNC(60),DMY(1000) ,
     6ARRAY5(61,61),AVE(60),SIGMA(60),COEN(60),SIGMCO(60),FLEVL(60)
      EQUIVALENCE(DATA ,Z)
          EQUIVALENCE(STDEV,COEN,X),(X(61),AVE(1))
C
C
256   PRIN =PRBIN*100.
      PROUT = PRBOUT*100.
      NO = 0
      WRITE OUTPUT TAPE 6,100,NOPROB,NODATA,NOTRMS,PRIN,PROUT
  100 FORMAT(21H1STEPWISE  REGRESSION//12H PROBLEM NO.I5//19H NO. OF DAT
     -A SETS =I5//22H NO. OF TERM CHOICES =I5//15H PROBABILITY OF/32H
     -  1) ERROR IN ENTERING TERM =F8.4,4H 0/0/32H     2) ERROR IN DELET
     -ING TERM =F8.4,4H 0/0//)
      CALL SUMSQ
      IF (IFCNST)111,222,111
  222 CALL RSDSUM
  111 CALL PRCRCN
C   CORE 6 ENABLES 'N' RANDOM TERM SELECTION PASSES,RETAINING BEST PASS
      ICOUNT =0
      M=1
      NINIT=NOINIT
```

```
      IF (NORAND)232,232,212
212   NINIT = 0
      M=3
      WRITE TAPE ITAPE9,(DEFR,((ARRAY5(IT1,IT2),IT1=1,NOZ),IT2=1,NOZ))
C        SAVES ARRAY5 AND DEFR FOR USE IN NRAND.
      WRITE OUTPUT TAPE 6,1001,NOPASS
1001  FORMAT(9HOPASS NO.,I5,20H     STANDARD TRIAL.    )
232   NOSTEP=-1
      DO 542 I=1,NOTRMS
542   INDEX(I)=0
      CALL RGRSSN(N,ICOUNT)
C        M=1 IF THERE ARE NO RANDOM TRIALS OR IF EACHSTEP OF REGRESSION
C        IS TO BE PRINTED.  M=3 IF THE STANDARD TRIAL WAS JUST PREFORMED
C        M=2 IF THE LAST STEP OF THE RANDOM TRIAL IS TO BE PRINTED.
      GO TO (601,600,501),M
501   ICOUNT = 1
      IF (IFSTEP) 700,700,701
700   M = 1
      GO TO 601
701   M = 2
      GO TO 601
600   CALL PRINT1(1)
601   CALL WINDUP
C        WINDUP DOES NOT RETURN IF THE SPECIFIED NUMBER OF RANDOM TRIALS
C        HAVE BEEN EXECUTED.
25    ICOUNT=ICOUNT+1
      IF (ICOUNT) 232,1,232
1     RETURN
      END                                                              *
```

```
$COMPILE MAD,PRINT OBJECT,PUNCH OBJECT                                  DATARD00
            EXTERNAL FUNCTION(NP,VEC)
            ENTRY TO DATARD.
            NORMAL MODE IS INTEGER
            DIMENSION V(72)
            K=0
            NOSPFN = (NP .RS. 18)
            I=1
READ        READ FORMAT $72C1*$,V...V(71)
            J=0
            THROUGH LOOP1,FOR I=0,1,I.G.71
            WHENEVER V(I).NE.$$
            V(J)=V(I)
            J=J+1
LOOP1       END OF CONDITIONAL
            THROUGH LOOP2,FOR I=J,1,I.G.71
LOOP2       V(I)=$$
            J1=0
            THROUGH L1, FOR K=K,1,K.G.NOSPFN
            THROUGH L2, FOR L=J1,1,V(L).E.$.$
            WHENEVER V(L).E.$$
            WHENEVER L.NE.J1,TRANSFER TO ERR
            W'R K .E. NOSPFN, F'N 0
             TRANSFER TO READ
L2          END OF CONDITIONAL
             GATHER.(VEC(K),$6C1*$,V(J1)...V(L-1) )
            WHENEVER V(L+1).E.$,$,L=L+1
L1          J1=L+1
            F'N 0
            VECTOR VALUES F=$6C1*$
  ERR       PRINT COMMENT$6***ERROR...ILLEGAL FORMATION IN SPECIAL FUNCTI
           1ON SPECIFICATIONS$
            F'N 1.
            END OF FUNCTION                                                *
```

```
$ASSEMBLE,PUNCH OBJECT                                          R+SET800
        SST     PROOFF,PROTON
        ENTRY   SET8
        ENTRY   RSET8
SET8    CLA*    1,4
BACK    SXA     OUT,4
        LDQ     8
        STQ     SAVE8
        TSX     PROOFF,4
        STO     8
        TSX     PROTON,4
OUT     AXT     **,4
        TRA     2,4
RSET8   CLA     SAVE8
        TRA     BACK
SAVE8   PZE
        END                                                             *
```